GEORGIA TECH GT–VSF
VLSI DESIGN VERIFICATION DOCUMENT

VLSI DEVELOPMENT REPORT
REPORT NO. VDR–0142–90–006
JULY 19, 1990

GUIDANCE, NAVIGATION AND CONTROL
DIGITAL EMULATION TECHNOLOGY LABORATORY

Contract No. DASG60–89–C–0142
Sponsored By
The United States Army Strategic Defense Command

COMPUTER ENGINEERING RESEARCH LABORATORY

Georgia Institute of Technology
Atlanta, Georgia 30332–0540

Contract Data Requirements List Item A006
Period Covered: Not Applicable
Type Report: As Required

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INTRODUCTION

There are eleven (11) Georgia Tech VLSI designs (see Table 1) in the AHAT Program. Each of these designs has been produced by Georgia Tech using the Genesil Silicon Compiler. Each design has passed the design verification process at Silicon Compiler Systems / Mentor Graphics and each has been fabricated in a bulk CMOS process (fabrication of certain chips was not complete when this document was released). Each of the Georgia Tech designs listed in Table 1 is being delivered to USASDC and to the Harris Corporation for conversion and fabrication in a rad–hard process. The program under which this work is done is AHAT (Advanced Hardened Avionics Technology). This document includes design information for the Georgia Tech spatial filter chip, GT–VSF.

Table 1. Georgia Tech Chip Set for AHAT

Design	DV Passed	Tape Delivered	Fabricated	Tested
GT–VFPU	1/17/89	5/10/90	5/19/89	4/4/90
GT–VNUC				
GT–VTF				
GT–VTHR				
GT–VCLS	1/26/90	7/12/90	7/13/90	
GT–VCTR	2/8/90	7/12/90	7/13/90	
GT–VIAG				
GT–VDAG				
GT–VSNI	1/17/89	5/23/90	4/14/89	4/4/90
GT–VSM8	1/17/89	6/8/90	5/6/89	4/4/90
GT–VSF	9/12/89	7/19/90	7/13/90	

DV CHECKLIST

1. DV CONTROL NUMBER :_____

2. CUSTOMER INFORMATION

Customer Name: Georgia Tech Chip Name: GT-VSF (Sfilter)

Address : 400 10th Street FAX : (404) 894-3120
CRB Room 377

Atlanta, GA 30332

Project Manager: Dr. C.O. Alford Phone: (404) 894-2505

Design Engineer: Amar Ghori Phone: (404) 894-2527

_____ Phone: _____

Test Engineer : Joseph Chamdani Phone: (404) 894-2527

3. SERVICES INFORMATION

XX Design Verification Service only. PO #_____

____ Prototype Service and Design Verification. PO #_____

____ 1.8% Maintanece

____ SCS Test ____ Foundry Test ____ Customer Test

When DV is complete, send verified physical database tape to

Customer (Y) N Silicon Vendor (Y) N

4. DV CONTACT: _____ Phone: _____

5. REGRESSION

5.1 GENESIL Version: 7.1
5.2 Name of Session Log from recompile: DV_session.LOG
5.3 Include DV_regression.CMD: DV_regression.001 (simulation and timing)
5.4 Size of database (MB): 80 Density: 6250____ 1600____ TK50____
Tar XX wbak ____ Apollo Cartridge____
(compressed) Sun Cartridge XX

6. FUNCTIONAL INFORMATION (check when included)

6.1 Key Parameters : ____
6.2 DV_pin_description : XX
6.3 Block Diagram : XX
6.4 Functional Description : XX
6.5 Timing Diagrams at Pins : ____
6.6 Annotated Views : XX Annotated Schematics: XX
6.7 Chip Text Specification on tape :____ Density: 6250___ 1600___ TK50___
Apollo Cartridge___
Sun Cartridge XX

7. PHYSICAL INFORMATION

7.1 Fabline Name : HP1-CIOA

Customer-Specific: Y (N) Fabline GENECAL Directory on tape: Y (N)

Fabline GENESIL Directory on tape : Y (N)

Fabline Calibration Status: Production: XX Beta:____ Alpha:____

NOTE: If not a production fabline, then approval from SCS is required.

7.2 Plots: (check when included or indicate filename)
Chip Route (D size): XX Bonding Diagram (B size) : XX
Route Filename: route_1.031 Bonding Filename: bond_1.031

7.3 Die Size: Reported Die Size: 335x311 square-mils
Maximum Acceptable Die Size (± 2%): 394x394 square-mils
Minimum Acceptable Die Size (± 2%): 234x234 square-mils

7.4 GENESIL Package Name : CPGA100e Spec included? Y (N)
Cavity/Well Size : 434 mils by 434 mils
Non-GENESIL Supplied Package? Y (N) Text Spec included on tape? Y (N)
Vendor Name/Part # : KYOCERA KD-82258B Foundry Approval? (Y) N

7.5 External Block: None

7.6 LRAM: Y (N) LROM: Y (N) LPLA: Y (N) LogicCompiler Blocks: (Y) N

7.7 Test Pad (PM Pad) is included? (Y) N (Required for PS)

7.8 Power Pad : 2 pair of Core Power 5 pair of Ring Power Pad
+1 ring VDD Pad

NP protection for nwell pad? (Y) N

Error in PADRING.033 (PADRING.DRC)? Y (N) Hardcopy attached? Y (N)

ESD requirements Normal Approved by SCS? (Y) N

8. ELECTRICAL INFORMATION

8.1 Chip Frequency
Specified in netlist: 10 MHz Target frequency: 3 MHz

8.2 Power Dissipation: GENESIL= 0.8 W at 10 MHz Spec= ____ W at ____ MHz

8.3 Operating Voltage: from 4.5 Volts to 5.5 Volts

9. SIMULATION

9.1 Number of Clocking Regimes : 1

	Clock Pad Name	DIV/NO_DIV	Ext Clock Name	Int PHASE_A/PHASE_B Name
1.	pixelclk	No_DIV	Pixel_clk	PHASE_A/PHASE_B
2.				
3.				
4.				
5.				

9.2 Simulation Setup Files:

Name: _____ Listings attached: _____

Description: _____

Affected Tests: _____

Name: _____ Listings attached: _____

Description: _____

Affected Tests: _____

Name: _____ Listings attached: _____

Description: _____

Affected Tests: _____

9.3 Test Vector Set:

Total No. of Vectors: 22,602

NOTE: Test vectors written one phase per vector have a maximum test frequency on the IMS Tester of 10 MHz.
Test vectors written one cycle per vector have a maximum test frequency on the IMS Tester of 20 MHz.

1. Name: add test_trace No of vectors: 164
   Description: manufacturing test for address

   Portions of Chip Tested: adders

   Pass with GFL model? xx
   Pass with GSL model? xx Use for PS testing? Y N
   Pass Fight Test? ____

2. Name: coefftest_trace No of vectors: 671
   Description:
   coefficient testing

   Portions of Chip Tested: _____

   Pass with GFL model? x
   Pass with GSL model? x Use for PS testing? Y N
   Pass Fight Test? ____

3. Name: dead pix_trace No of vectors: 194
   Description:
   dead pixel condition testing

   Portions of Chip Tested: _____

   Pass with GFL model? xx
   Pass with GSL model? xx Use for PS testing? Y N
   Pass Fight Test? ____

4. Name: frame 10x10 trace No of vectors: 150
Description:

Portions of Chip Tested:

Pass with GFL model? xx
Pass with GSL model? xx Use for PS testing? Y N
Pass Fight Test? ____

5. Name: frame10x128 trace No of vectors: 680
Description:

Portions of Chip Tested:

Pass with GFL model? xx
Pass with GSL model? xx Use for PS testing? Y N
Pass Fight Test? ____

6. Name: frame128x128 trace No of vectors: 16552
Description:
Description:

Portions of Chip Tested:

Pass with GFL model? xx
Pass with GSL model? xx Use for PS testing? Y N
Pass Fight Test? ____

7. Name: frame13x15 trace No of vectors: 250
Description:

Portions of Chip Tested:

Pass with GFL model? xx
Pass with GSL model? xx Use for PS testing? Y N
Pass Fight Test? ____

8. Name: frame19x17x2_trace No of vectors: 706
Description:

Portions of Chip Tested:

Pass with GFL model? xx
Pass with GSL model? xx Use for PS testing? Y N
Pass Fight Test? ____

9. Name: frame5x5_trace No of vectors: 71
Description:

Portions of Chip Tested:

Pass with GFL model? xx
Pass with GSL model? xx Use for PS testing? Y N
Pass Fight Test? ____

10. Name: interface_trace No of vectors: 500
Description:
Description: host interface testing

Portions of Chip Tested:

Pass with GFL model? xx
Pass with GSL model? xx Use for PS testing? Y N
Pass Fight Test? ____

11. Name: multa_trace No of vectors: 433
Description:
multiplier A testing

Portions of Chip Tested:

Pass with GFL model? xx
Pass with GSL model? xx Use for PS testing? Y N
Pass Fight Test? ____

12. **Name:** multb_trace **No of vectors:** 400
Description: mult B testing

Portions of Chip Tested:

Pass with GFL model? xx
Pass with GSL model? xx **Use for PS testing?** Y N
Pass Fight Test?

13. **Name:** multc_trace **No of vectors:** 293
Description: mult C testing

Portions of Chip Tested:

Pass with GFL model? xx
Pass with GSL model? xx **Use for PS testing?** Y N
Pass Fight Test?

14. **Name:** multd_trace **No of vectors:** 267
Description:
Description: mult D testing

Portions of Chip Tested:

Pass with GFL model? xx
Pass with GSL model? xx **Use for PS testing?** Y N
Pass Fight Test?

15. **Name:** out_trace **No of vectors:** 197
Description: output testing

Portions of Chip Tested:

Pass with GFL model? xx
Pass with GSL model? xx **Use for PS testing?** Y N
Pass Fight Test?

16. Name: pipetest_trace No of vectors: 1074
Description: Pipe testing

Portions of Chip Tested: _____

Pass with GFL model? xx
Pass with GSL model? xx Use for PS testing? Y N
Pass Fight Test? ____

17. Name: _____ No of vectors: _____
Description: _____

Portions of Chip Tested: _____

Pass with GFL model? ___
Pass with GSL model? ___ Use for PS testing? Y N
Pass Fight Test? ____

18. Name: _____ No of vectors: _____
Description: _____
Description: _____

Portions of Chip Tested: _____

Pass with GFL model? ___
Pass with GSL model? ___ Use for PS testing? Y N
Pass Fight Test? ____

9.4 IMS Grouping within limitation? Y N (Required for PS only)

9.5 Tester clock frequency = 3 MHz

9.6 Signals that must be glitch free: Y N

	Signal Name	Ran GSL with glitch detection feature on?
1.	_____	Y N
2.	_____	Y N
3.	_____	Y N
4.	_____	Y N
5.	_____	Y N

Name: _____ Listings attached: _____
Temperature: _____ Voltage: _____
Description : _____
_____
_____

10.4 Critical Boundary Conditions:

List critical paths here or annotate the timing report.
Attach additional pages if needed.

Clock Name: Pixel_clk _____

	report	limit (± 5%)	report	limit (± 5%)
1. Phase 1 High	104.7ns	165 ns	_____	_____
2. Phase 2 High	162.7 ns	165 ns	_____	_____
3. Symmetric Cycle	325.5 ns	330 ns	_____	_____
4. Minimum Cycle	267.4 ns	330 ns	_____	_____

Outputs

	Signal Name	load (pF)	delay	limit
1.	_____	_____	_____	_____
2.	_____	_____	_____	_____
3.	_____	_____	_____	_____
4.	_____	_____	_____	_____
5.	_____	_____	_____	_____
6.	_____	_____	_____	_____
7.	_____	_____	_____	_____
8.	_____	_____	_____	_____
9.	_____	_____	_____	_____
10.	_____	_____	_____	_____

Inputs

	Signal Name	setup report/limit	hold report/limit
1.	_____	_____/_____	_____/_____
2.	_____	_____/_____	_____/_____
3.	_____	_____/_____	_____/_____
4.	_____	_____/_____	_____/_____
5.	_____	_____/_____	_____/_____
6.	_____	_____/_____	_____/_____
7.	_____	_____/_____	_____/_____
8.	_____	_____/_____	_____/_____
9.	_____	_____/_____	_____/_____
10.	_____	_____/_____	_____/_____

10.5 Hold Time Violations: none (At 1.7 nsec.)

11. DC CHARACTERISTICS

PARAMETERS	DESCRIPTION	CONDITIONS 0 to 70	CONDITIONS -55 to +125	MIN	MAX
DATA PAD INPUT ONLY					
VIH	Input High Voltage			2.0V	
VIL	Input Low Voltage				0.8V
IIL	Input Leakage	VSS<Vin<VDD	VSS<Vin<VDD	-10uA	10uA
CIN	Input Capacitance				6.0pf
DATA PAD OUTPUT ONLY					
VOH	Output High Voltage	VDD= 4.5V IOH=-2.2	VDD= 4.5V IOH=-2mA	2.4V	
VOL	Output Low Voltage	VDD= 4.5V IOL= 6mA	VDD= 4.5V IOL= 5mA		0.4V
IOZ	Output Leakage current(high Z)	VSS<Vout<VDD	VSS<Vout<VDD	-10uA	10uA
COUT	Output Capacitance				7.0pf
DATA PAD INPUT/OUTPUT					
VOH	Output High Voltage	VDD= 4.5V IOH=-2.2	VDD= 4.5V IOH=-2mA	2.4V	
VOL	Output Low Voltage	VDD= 4.5V IOL= 6mA	VDD= 4.5V IOL= 5mA		0.4V
VIH	Input High Voltage			2.0V	
VIL	Input Low Voltage				0.8V
IOZ	Output leakage current (high Z)	VSS<Vout<VDD	VSS<Vout<VDD	-10uA	10uA
CIO	Input/Output Capacitance				7.0pf
CLOCK PAD					
VIH	Input High Voltage			3.9V	
VIL	Input Low Voltage				0.6V
IIL	Input Leakage	VSS<Vin<VDD	VSS<Vin<VDD	-10uA	10uA
CIN	Input Capacitance				15pf

NOTE: All parameters at a supply voltage of VDD = 5V ± 10%.

12. CUSTOMER COMMENTS
Pre-Verification Comments

Three sets of vector files are provided as explained below

'name'.083 = normal vector file created from .089 file

'name'_trace.083 = trace object file

'name trace.coll 083 = collapsed trace file using "collapse" program.

13. CUSTOMER APPROVAL

The undersigned understands that if any design changes are initiated by the Customer subsequent to this sign-off, the Customer is liable for any charges imposed by Silicon Compiler Systems as agreed to in either the Design Verification Terms & Conditions or the Prototype Services Terms & Conditions. In addition, such changes require the DV process to be started from the beginning, which results in extended DV schedules.

Customer Approval : _____ Date 8/30/89

Title : Research Engineer - I

14. SCS APPROVAL
Pre-Verification Comments

SCS Approval: _____ Date ___/___/___
Regional Field Application Consultant

SCS Approval: _____ Date ___/___/___
Technical Support Team Leader

GT-VSF: SPATIAL FILTER

INTRODUCTION

The Spatial Filter chip implements a 9-point bi-symmetric filter. The purpose of this chip is to eliminate or suppress noise in the image frame through spatial filtering. The chip is designed to handle arbitrary frame sizes from 5x5 pixels upto 128x128 pixels. Frame size is determined automatically by the chip based on incoming signals and the chip is appropriately configured. The chip is also designed to handle dead pixels between consequetive rows as well as dead pixels between consequetive frames. The chip accepts a 16-bit unsigned pixel intensity as input and provides a 17-bit filtered output in sign magnitude format. Filter coefficients are loaded into the chip through the host. The host may also read back these coefficients at any time. Due to the nature of the algorithm, the chip introduces a latency of 130 clock cycles

FUNCTIONALITY

The filtered intensity of each pixel is computed as a weighted sum of the intensities of its nearest neighbors as well as itself. These weights are pre-loaded by the host when the chip is in the "load" state. The weights are in 16 bit sign magnitude format with 1-bit integer and 14-bit fraction resolution. Thus the range of the weights is -1.999999 to +1.999999 with a resolution of 2^{-13}.

The exact I/O relation for this chip are as follows.

Let the filter coefficients be labelled as shown below and let Q be the output function of the chip.

A	B	A
C	D	C
A	B	A

Then,

$$Q(P_k) = A(P_{k-129} + P_{k-127} + P_{k+127} + P_{k+129}) + B(P_{k-128} + P_{k+128}) + C(P_{k-1} + P_{k+1}) + DP_k \quad \text{---- (1)}$$

where,

P_n = The intensity of pixel n

$Q(P_k)$ = The output intensity for pixel k

A causal form of equation (1) is :

$$Q(P_{k-129}) = A(P_{k-258} + P_{k-256} + P_{k-2} + P_k) + B(P_{k-257} + P_{k-1}) + C(P_{k-130} + P_{k-127}) + DP_{k-129} \quad \text{---- (2)}$$

The primary function of the Spatial filter chip is to implement equation (2). Secondary requirements are listed below.

(1). Filter coefficients must be loadable at all times.
(2). Pixel intensities should be output every cycle after the initial latency.
(3). The end of a frame should be signalled by the chip.
(4). For the purpose of computation, frame edges behave as pixels with null intensity.

INPUT/OUTPUT

INPUTS

Signal	Timing	Description
Pixel_in[15:0]	VB(t)	Data signal denoting intensity of current pixel.
Begin_Frame_in	VB(t)	Active high. When active, it signals the beginning of current frame.
End_Frame_in	VB(t)	Active high. When active, it signals the end of current frame.
Begin_Row_in	VB(t)	Active high. When active, it signals the start of current row.
End_Row_in	VB(t)	Active high. When active, it signals the end of current row.
Reset	VB(t)	Active high. When active, it resets the chip.
Pixel_clk	N/A	Clock signal.
Addr[7:0]	VB(t)	Host address bus.
Ios	VB(t)	Host control signal for read/write interface.
Chip_Id[3:0]	VB(t)	4-bit Chip Id. Used to select chip.
Dev_select[3:0]	VB(t)	Host signal. Selects the chip if it matches chip-id
Ode	VB(t)	Output device enable. Host control signal.

OUTPUTS

Signal	Timing	Description

Pixel_out[15:0]	PROP	Data signal denoting intensity of pixel after filtering.
Begin_Frame_out	SB(t)	Active high. When active, it signals the beginning of current frame.
End_Frame_out	SB(t)	Active high. When active, it signals the end of current frame.
Begin_Row_out	SB(t)	Active high. When active, it signals the start of current row.
End_Row_out	SB(t)	Active high. When active, it signals the end of current row.

BI-DIRECTIONAL

Data[15:0]	SB(t)/VB(t)	Host data bus. Used to read and write to chip.

CHIP DESIGN

The chip is composed of the following major components

Pipe: This is a 129 stage memory structure that stores incoming pixel intensities and makes them available to the computational element of the chip at the appropriate time. The pipe also contains control circuitry to determine the size of the incoming image frame and configures itself appropriately. This frame size is held constant till the chip is reset.

sumA: A simple computational module that adds the intensities that are to be multiplied by weight A.

$$sumA := P_k + P_{k-2} + P_{k-256} + P_{k-258}$$

sumB: This module adds the intensities that are to be multiplied by weight B.

$$sumB := P_{k-1} + P_{k-257}$$

sumC: This module adds the intensities that are to be multiplied by weight C.

$$sumC := P_{k-129} + P_{k-127}$$

multA: This module multiplies the output of sumA by coefficient A.

multB: This module multiplies the output of sumB by coefficient B.

multC: This module multiplies the output of sumC by coefficient C.

multD: This module multiplies P_{k-128} by coefficient D.

Output: This module adds the outputs from multA, multB, multC and multD, converts the result to sign magnitude form and sets the output to maximum intensity if overflow occurs.

Host Interface: This module provides the circuitry required to interface with a fast host. The interface is designed to handle a host whose clock speed is an integer multiple of the chip clock speed.

Control: This module provides address decoding, sequencing and other related features. Control signals to all of the above blocks are generated by this module.

LAYOUT , TIMING & POWER DISSIPATION

The design is implemented in NCR 1.0 micron VLSI process. The die size for this chip is 335x311 sq. mils. Preliminary timing figures show a cycle time of 275ns. Power dissipation is 0.8 Watts.

FUNCTIONAL TEST

The design was successfully tested with various image frames. The frames used are listed below.

	Frame size	Type
	5x5	Normal pixel intensities.
	10x10	Very high pixel intensities.
	10x10	Negative pixel intensities.
	128x10	Normal pixel intensities.
	128x128	Normal pixel intensities.
Scene	19x17x2	Dead pixels between frames. Second frame with very high pixel values.
	10x10	Dead pixels between rows.

PACKAGING

The chip uses a 100 pin Ceramic Pin Grid Array.

/***/
/* Pin Description of Spatial Filter Chip (GT-VSF) */
/***/

PIN_#	ABBREVIATED NAME	SIGNAL_NAME	PAD_TYPE	TIMING
1	VDD	VDD	VDD CORNER	
2	Data[5]	Data[5]	DATA IO	SB/VB
3	Data[6]	Data[6]	DATA IO	SB/VB
4	Data[7]	Data[7]	DATA IO	SB/VB
5	Data[8]	Data[8]	DATA IO	SB/VB
6	Data[9]	Data[9]	DATA IO	SB/VB
7	Data[10]	Data[10]	DATA IO	SB/VB
8	Data[11]	Data[11]	DATA IO	SB/VB
9	Data[12]	Data[12]	DATA IO	SB/VB
10	Data[13]	Data[13]	DATA IO	SB/VB
11	Data[14]	Data[14]	DATA IO	SB/VB
12	Data[15]	Data[15]	DATA IO	SB/VB
13	Pxl_in[0]	Pixel_in[0]	DATA IN	VB
14	Pxl_in[1]	Pixel_in[1]	DATA IN	VB
15	Pxl_in[2]	Pixel_in[2]	DATA IN	VB
16	Pxl_in[3]	Pixel_in[3]	DATA IN	VB
17	Pxl_in[4]	Pixel_in[4]	DATA IN	VB
18	Pxl_in[5]	Pixel_in[5]	DATA IN	VB
19	Pxl_in[6]	Pixel_in[6]	DATA IN	VB
20	Pxl_in[7]	Pixel_in[7]	DATA IN	VB
21	VSS	VSS	VSS RING	
22	Pxl_in[8]	Pixel_in[8]	DATA IN	VB
23	Pxl_in[9]	Pixel_in[9]	DATA IN	VB
24	Pxl_in[10]	Pixel_in[10]	DATA IN	VB
25	VSS	VSS	VSS CORE	
26	VSS	VSS	VSS CORNER	
27	Pxl_in[11]	Pixel_in[11]	DATA IN	VB
28	Pxl_in[12]	Pixel_in[12]	DATA IN	VB
29	Pxl_in[13]	Pixel_in[13]	DATA IN	VB
30	Pxl_in[14]	Pixel_in[14]	DATA IN	VB
31	Pxl_in[15]	Pixel_in[15]	DATA IN	VB
32	Multtest	Multtest	DATA IN	VB
33	VDD	VDD	VDD RING	
34	Addtest	Addertest	DATA IN	VB
35	VDD	VDD	VDD CLOCK	
36	VSS	VSS	VSS CLOCK	
37	Pxl_Clk	Pixel_clk	CLOCK	
38	VDD	VDD	VDD CORE	
39	N_reset	N_reset	DATA IN	WA
40	Erow_in	End_row_in	DATA IN	VB
41	Brow_in	Begin_row_in	DATA IN	VB
42	VSS	VSS	VSS RING	
43	Bfrm_in	Begin_frame_in	DATA IN	VB
44	Efrm_in	End_frame_in	DATA IN	VB
45	Bfrm_out	Begin_frame_out	DATA OUT	SB
46	Efrm_out	End_frame_out	DATA OUT	SB
47	Brow_out	Begin_row_out	DATA OUT	SB
48	Ode	Ode	DATA IN	VB
49	-			
50	-			
51	VDD	VDD	VDD CORNER	
52	Ios	Ios	DATA IN	VB
53	DR_n_aDR	DR_n_aDR	DATA OUT	SB
54	Erow_out	End_row_out	DATA OUT	SB
55	Host_adr[4]	Host_addr[4]	DATA IN	VB
56	Host_adr[3]	Host_addr[3]	DATA IN	VB
57	Host_adr[2]	Host_addr[2]	DATA IN	VB
58	Host_adr[1]	Host_addr[1]	DATA IN	VB

59	Host_adr[0]	Host_addr[0]	DATA IN	VB
60	Dev_sel[0]	Dev_select[0]	DATA IN	VB
61	Dev_sel[1]	Dev_select[1]	DATA IN	VB
62	Dev_sel[2]	Dev_select[2]	DATA IN	VB
63	Dev_sel[3]	Dev_select[3]	DATA IN	VB
64	Pix_lsb[2]	Pix_lsb[2]	DATA OUT	SB
65	Pix_lsb[1]	Pix_lsb[1]	DATA OUT	SB
66	Pix_lsb[0]	Pix_lsb[0]	DATA OUT	SB
67	VDD	VDD	VDD RING	
68	Pix_msb[2]	Pix_msb[2]	DATA OUT	SB
69	Pix_msb[1]	Pix_msb[1]	DATA OUT	SB
70	Pix_msb[0]	Pix_msb[0]	DATA OUT	SB
71	Chip_id[3]	Chip_id[3]	DATA IN	VB
72	Chip_id[2]	Chip_id[2]	DATA IN	VB
73	Chip_id[1]	Chip_id[1]	DATA IN	VB
74	Chip_id[0]	Chip_id[0]	DATA IN	VB
75	Sign	Sign	DATA OUT	SB
76	VSS	VSS	VSS CORNER	
77	VDD	VDD	VDD CORNER	
78	Pxl_out[0]	Pixel_out[0]	DATA OUT	SB
79	Pxl_out[1]	Pixel_out[1]	DATA OUT	SB
80	Pxl_out[2]	Pixel_out[2]	DATA OUT	SB
81	Pxl_out[3]	Pixel_out[3]	DATA OUT	SB
82	Pxl_out[4]	Pixel_out[4]	DATA OUT	SB
83	Pxl_out[5]	Pixel_out[5]	DATA OUT	SB
84	Pxl_out[6]	Pixel_out[6]	DATA OUT	SB
85	Pxl_out[7]	Pixel_out[7]	DATA OUT	SB
86	VDD	VDD	VDD RING	
87	Pxl_out[8]	Pixel_out[8]	DATA OUT	SB
88	Pxl_out[9]	Pixel_out[9]	DATA OUT	SB
89	Pxl_out[10]	Pixel_out[10]	DATA OUT	SB
90	Pxl_out[11]	Pixel_out[11]	DATA OUT	SB
91	Pxl_out[12]	Pixel_out[12]	DATA OUT	SB
92	Pxl_out[13]	Pixel_out[13]	DATA OUT	SB
93	VSS	VSS	VSS RING	
94	Pxl_out[14]	Pixel_out[14]	DATA OUT	SB
95	Pxl_out[15]	Pixel_out[15]	DATA OUT	SB
96	Data[0]	Data[0]	DATA IO	SB/VB
97	Data[1]	Data[1]	DATA IO	SB/VB
98	Data[2]	Data[2]	DATA IO	SB/VB
99	Data[3]	Data[3]	DATA IO	SB/VB
100	Data[5]	Data[4]	DATA IO	SB/VB

Note:
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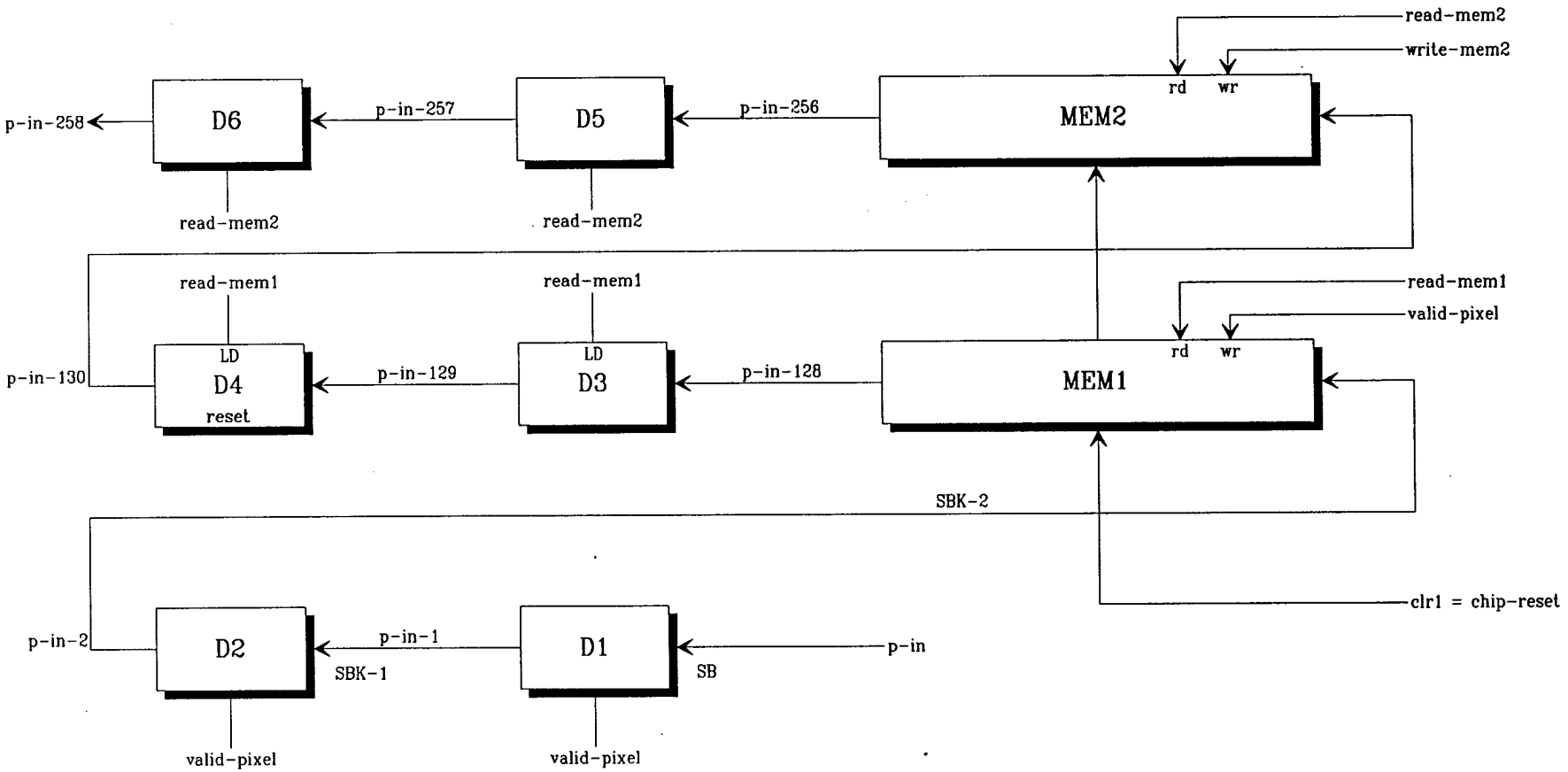
(1) TIMING = SB/VB means the bidirectional pad has SB output timing and VB input timing.

(2) TIMING = WA means valid at both clock phases, VA and VB.



Schematic of data-flow pipe

April 19, 1989

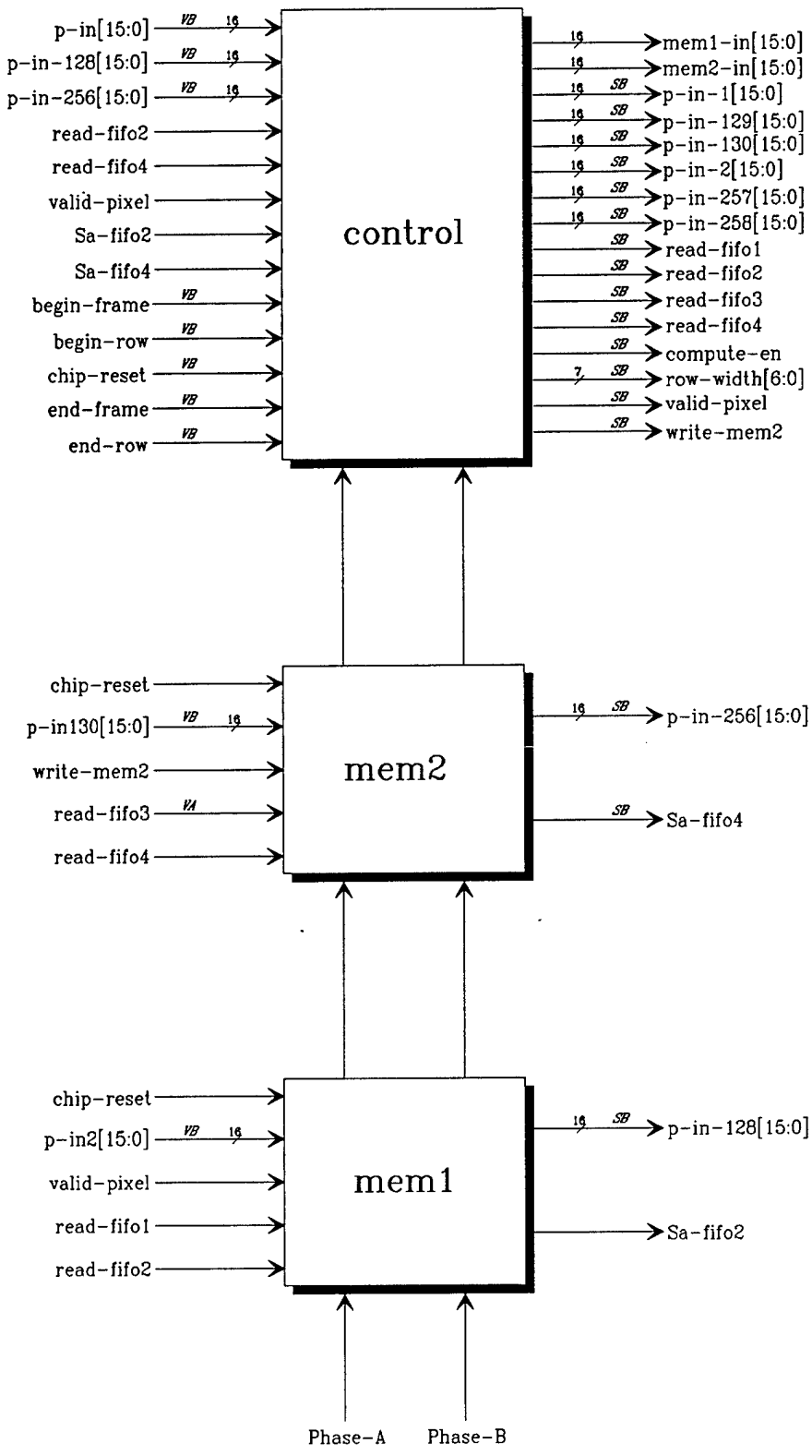
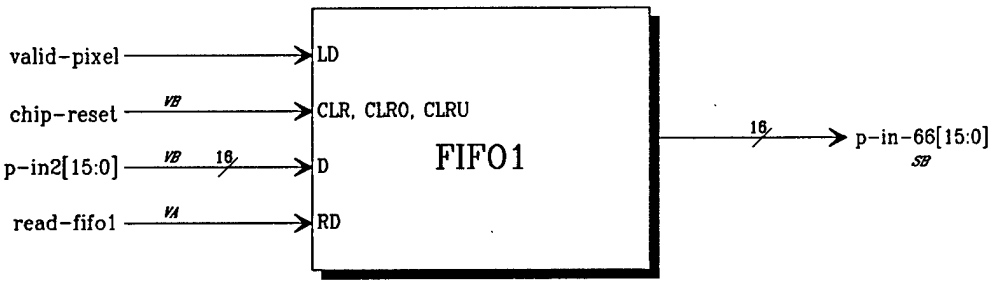
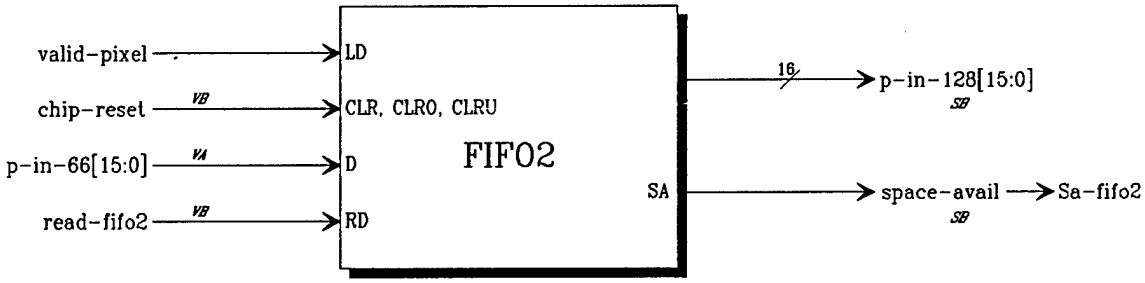


Fig. 1 /SFILTER/PIPE

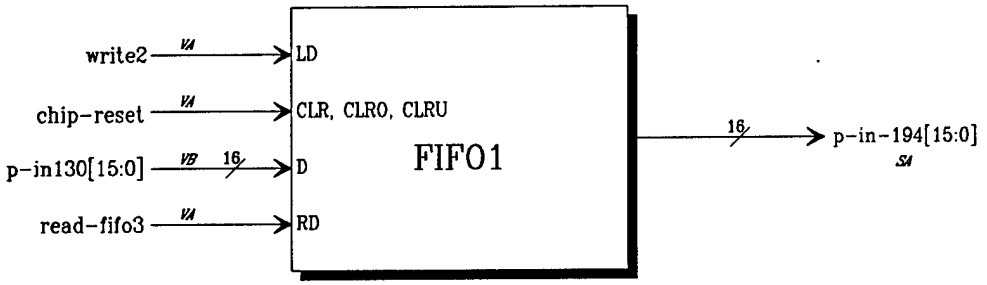
June 14, 1989

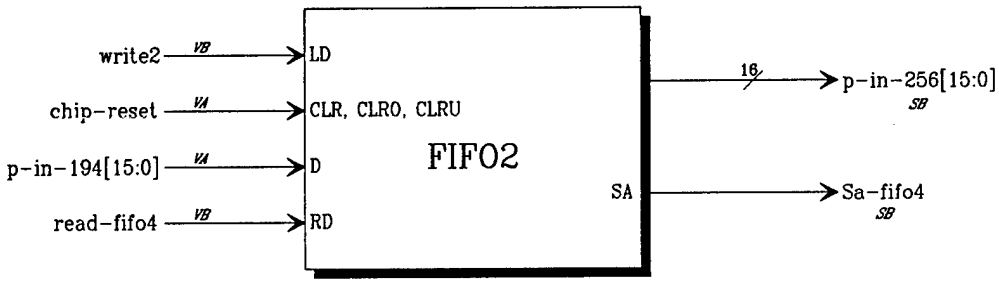




/SFILTER/PIPE/MEM1

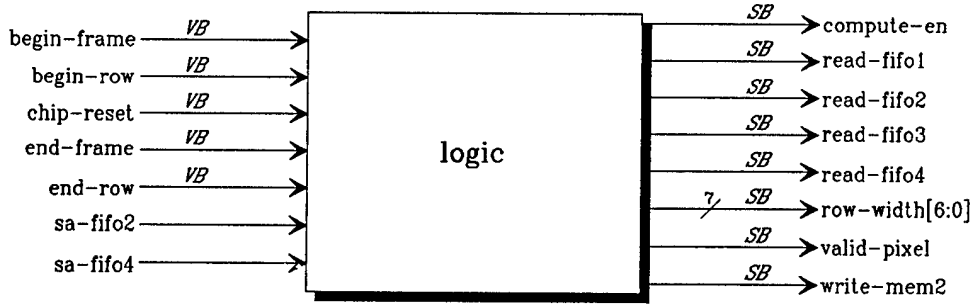
June 13, 1989

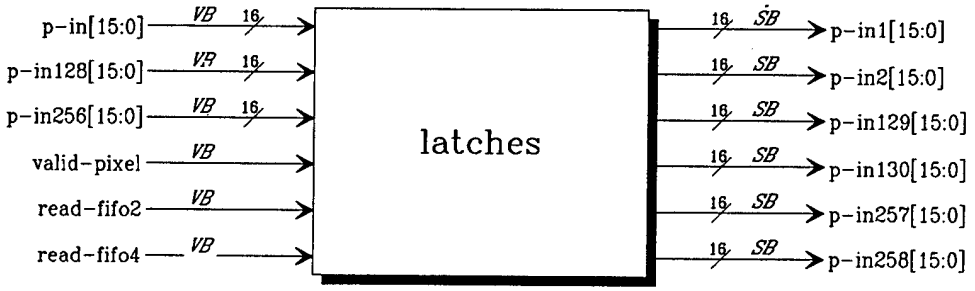




/SFILTER/PIPE/MEM2

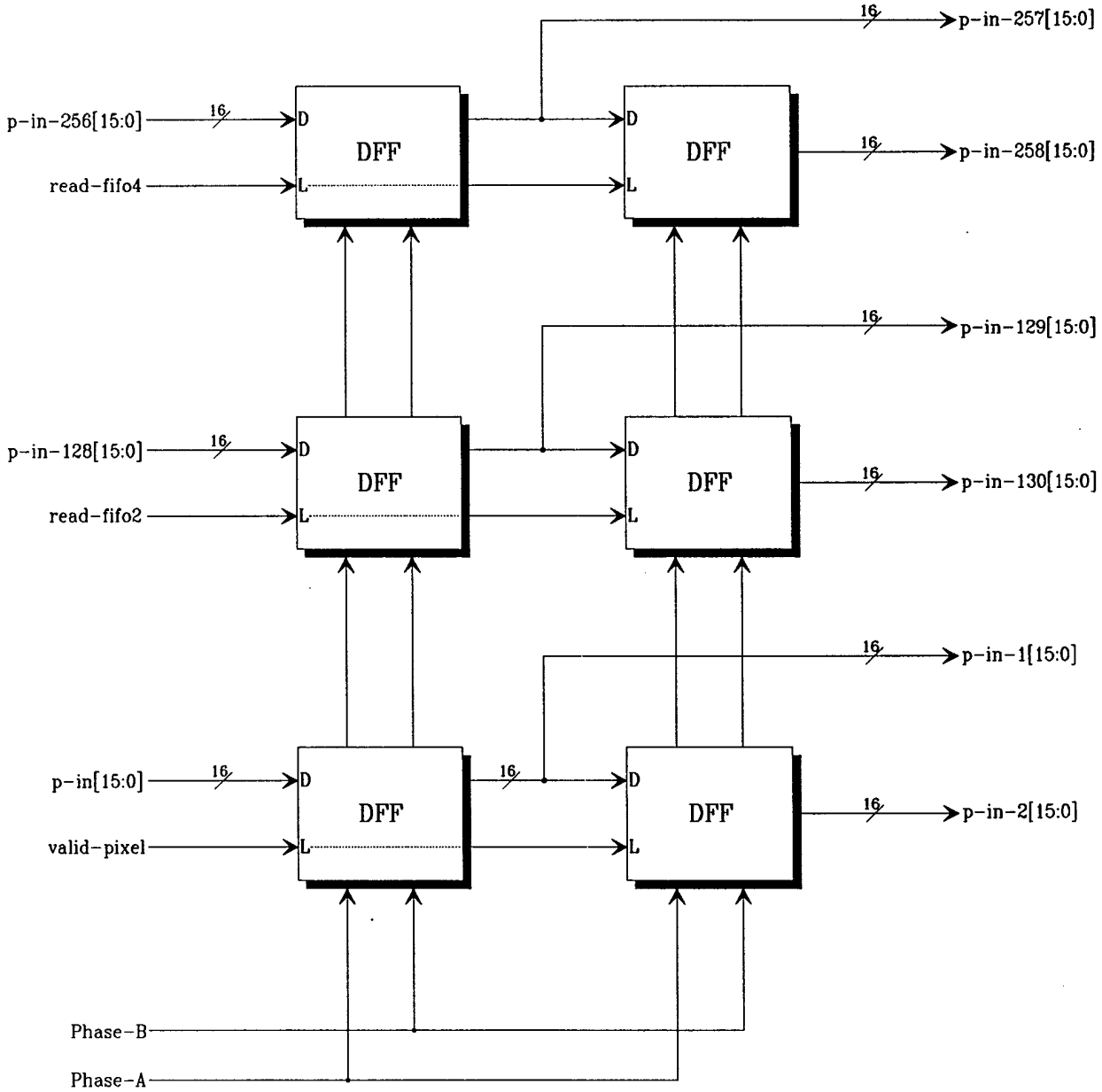
June 13, 1989





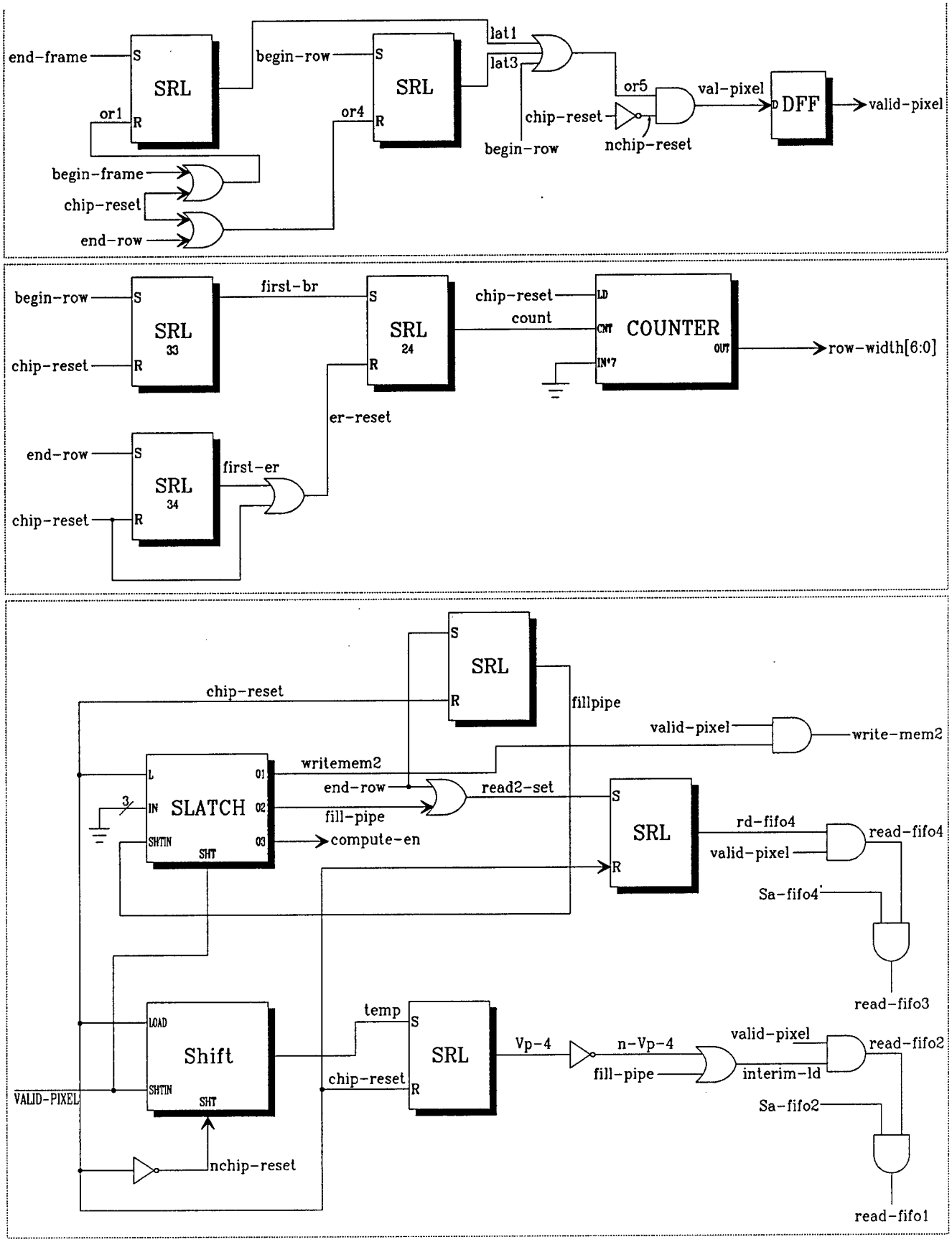
/SFILTER/PIPE/CONTROL

June 13, 1989



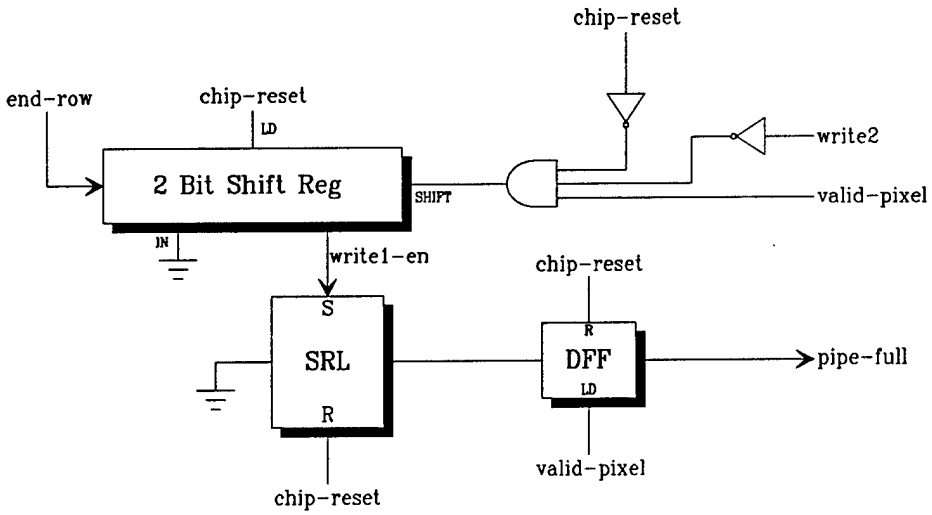
/SFILTER/PIPE/CONTROL/LATCHES

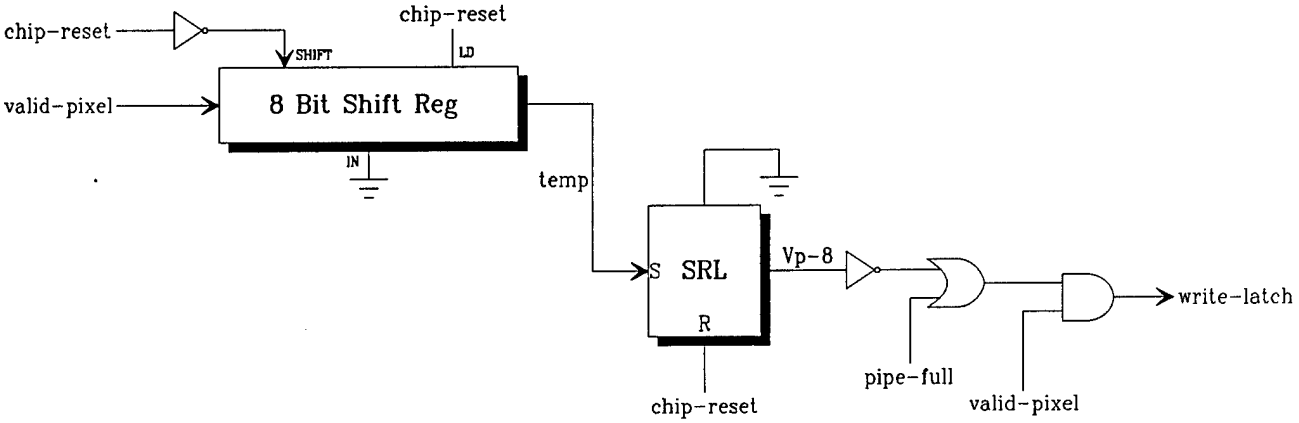
June 14, 1989



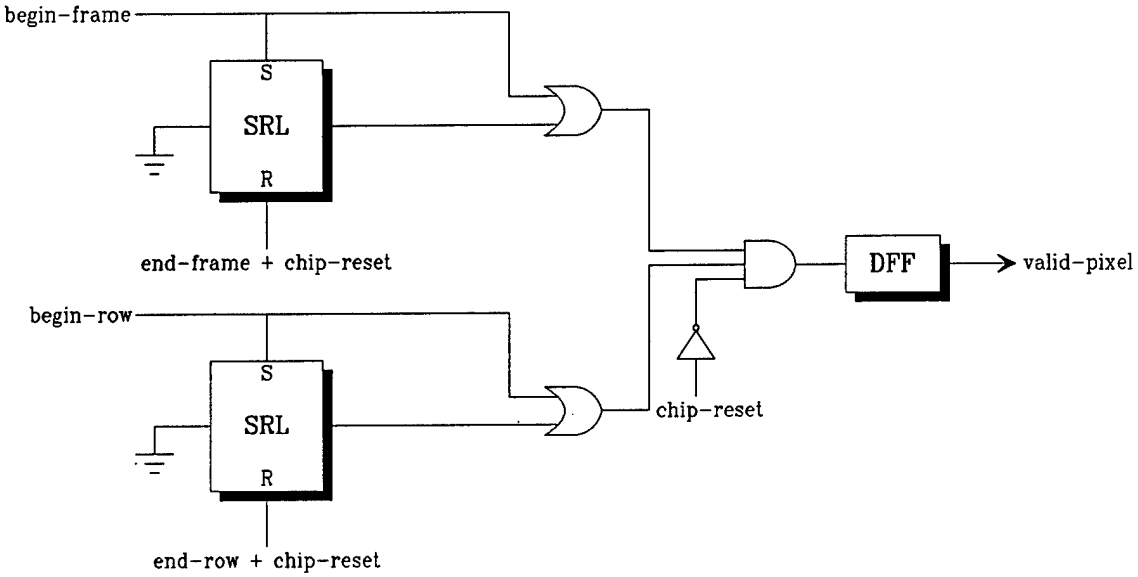
/SFILTER/PIPE/CONTROL/logic

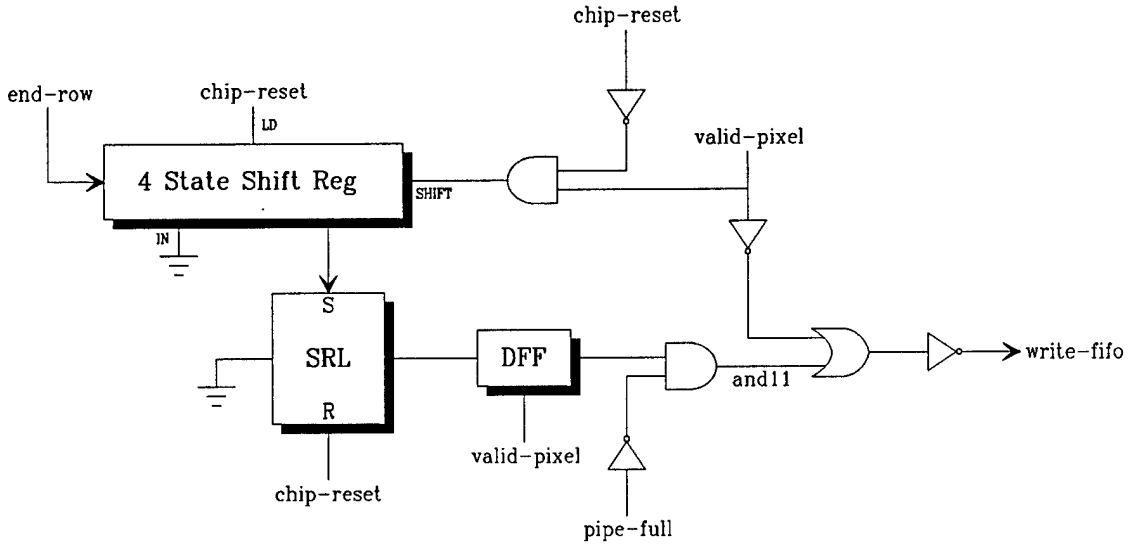
June 14, 1989





Schematic of pipe/control (page 2/2)





Schematic of pipe/control (page 1/2)

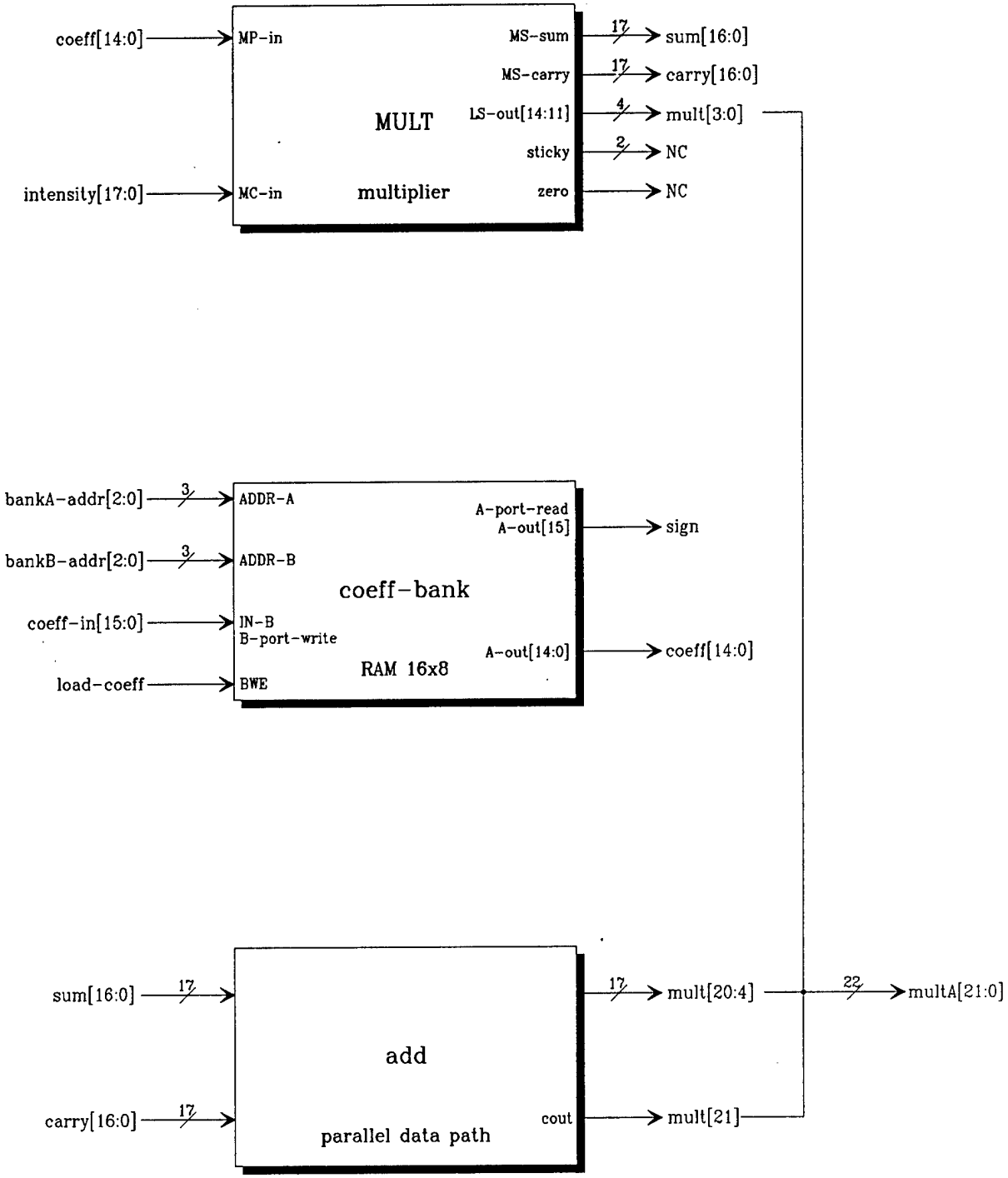


Fig. 3 /SFILTER/MULTA

May 10, 1989

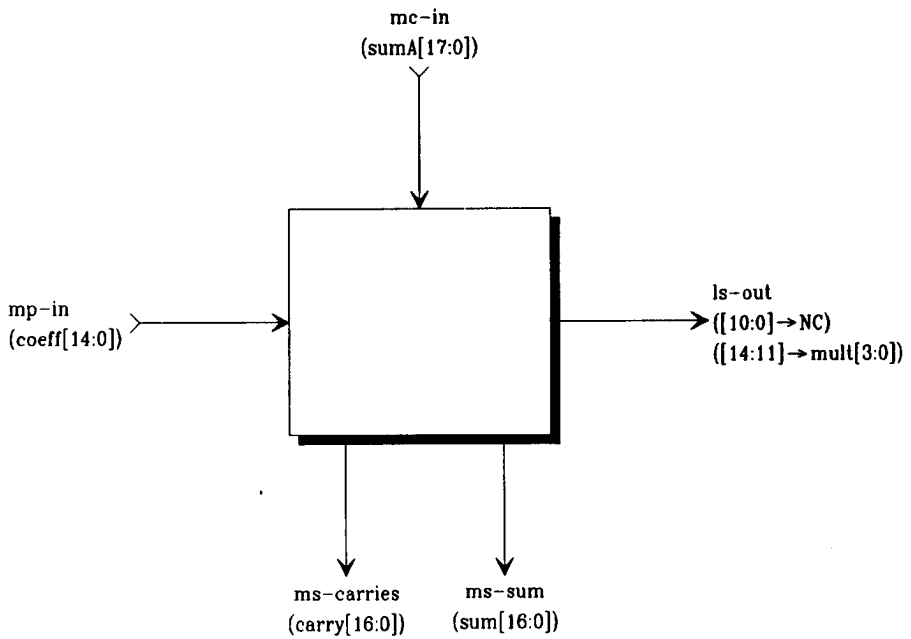


Fig 3A sfilter/multA/mult

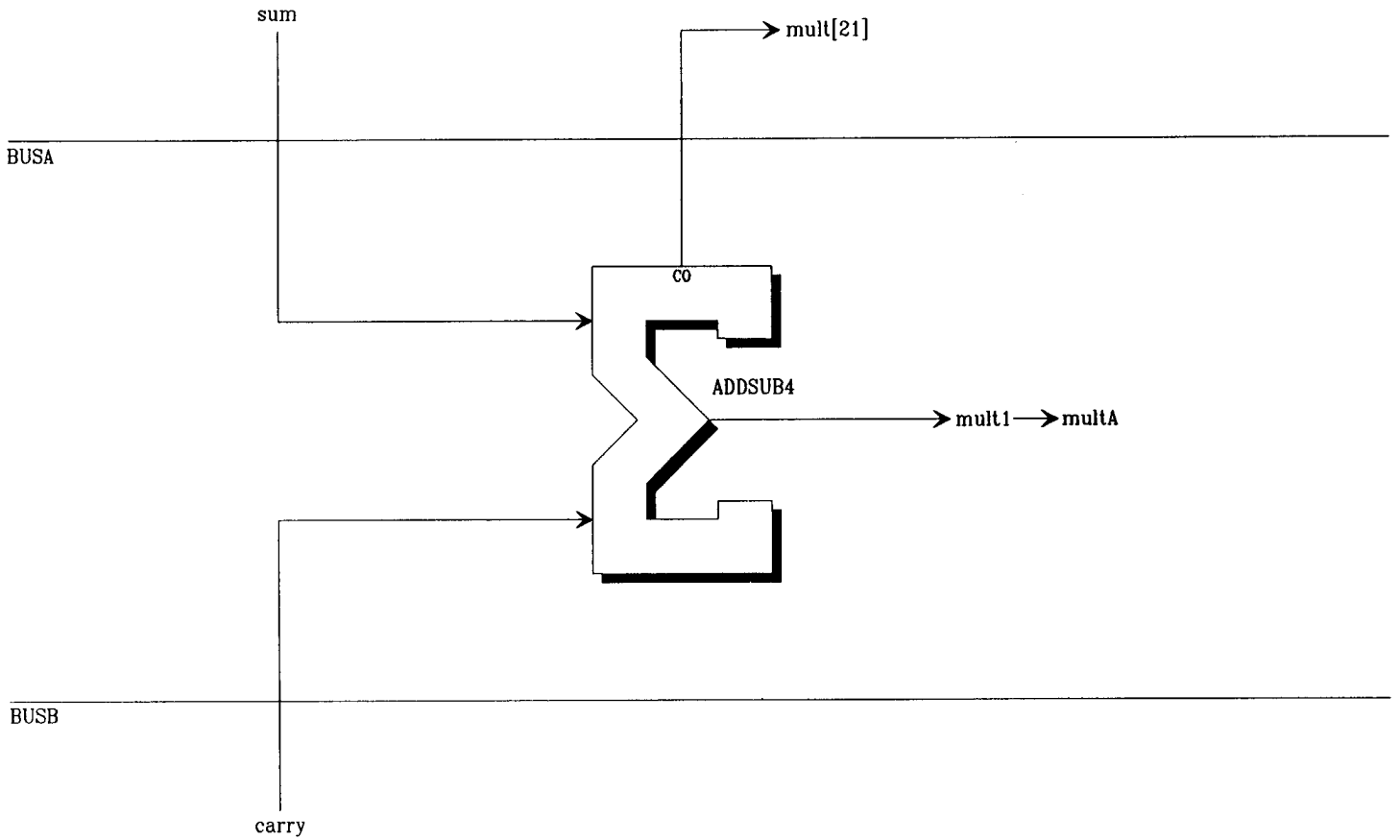


Fig 26 /SFILTER/multA/add

May 4, 1989

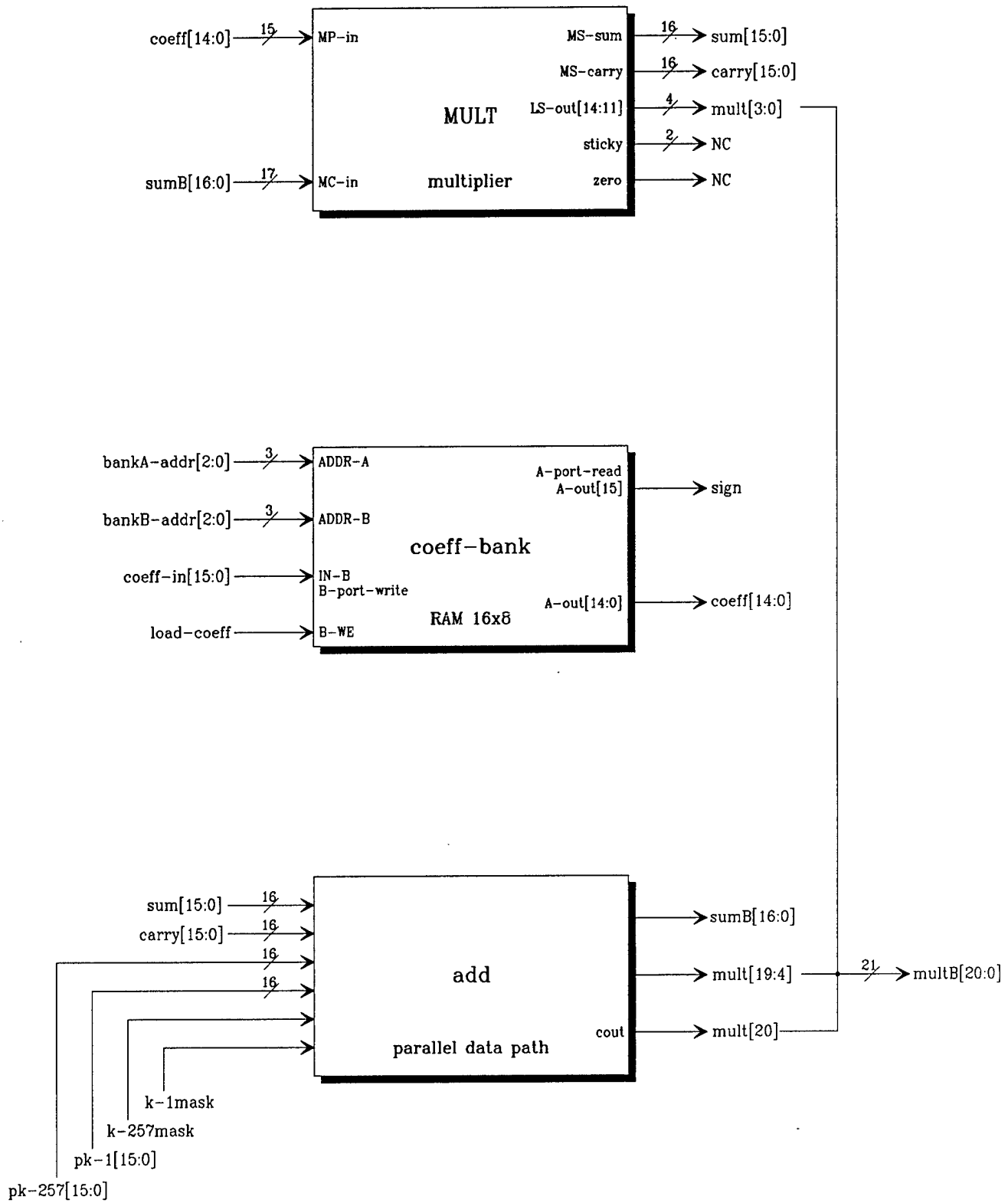


Fig. 4 /SFILTER/MULTB

May 10, 1989

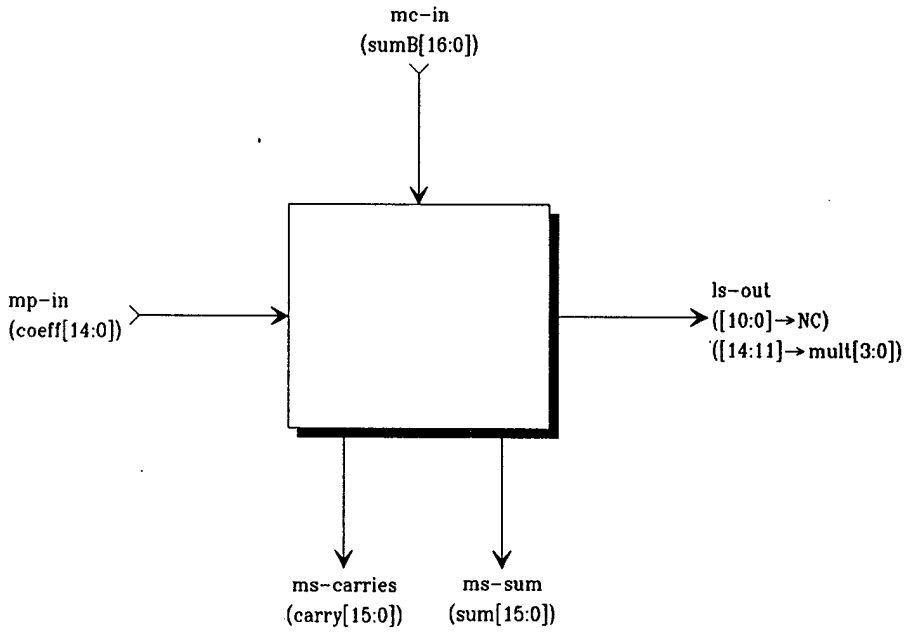


Fig 4A sfilter/multB/mult

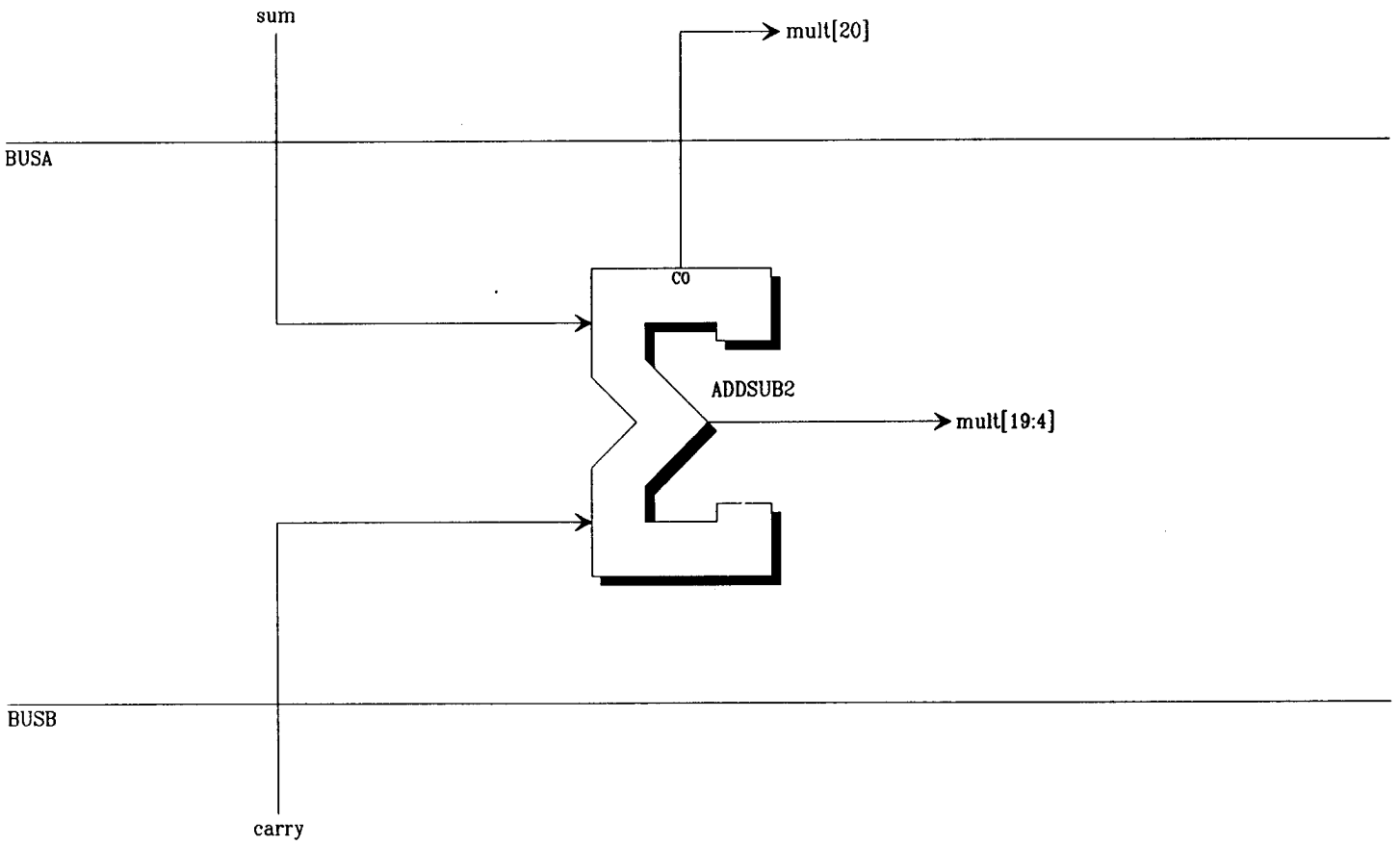


Fig 4B /SFILTER/multB/add

May 5, 1989

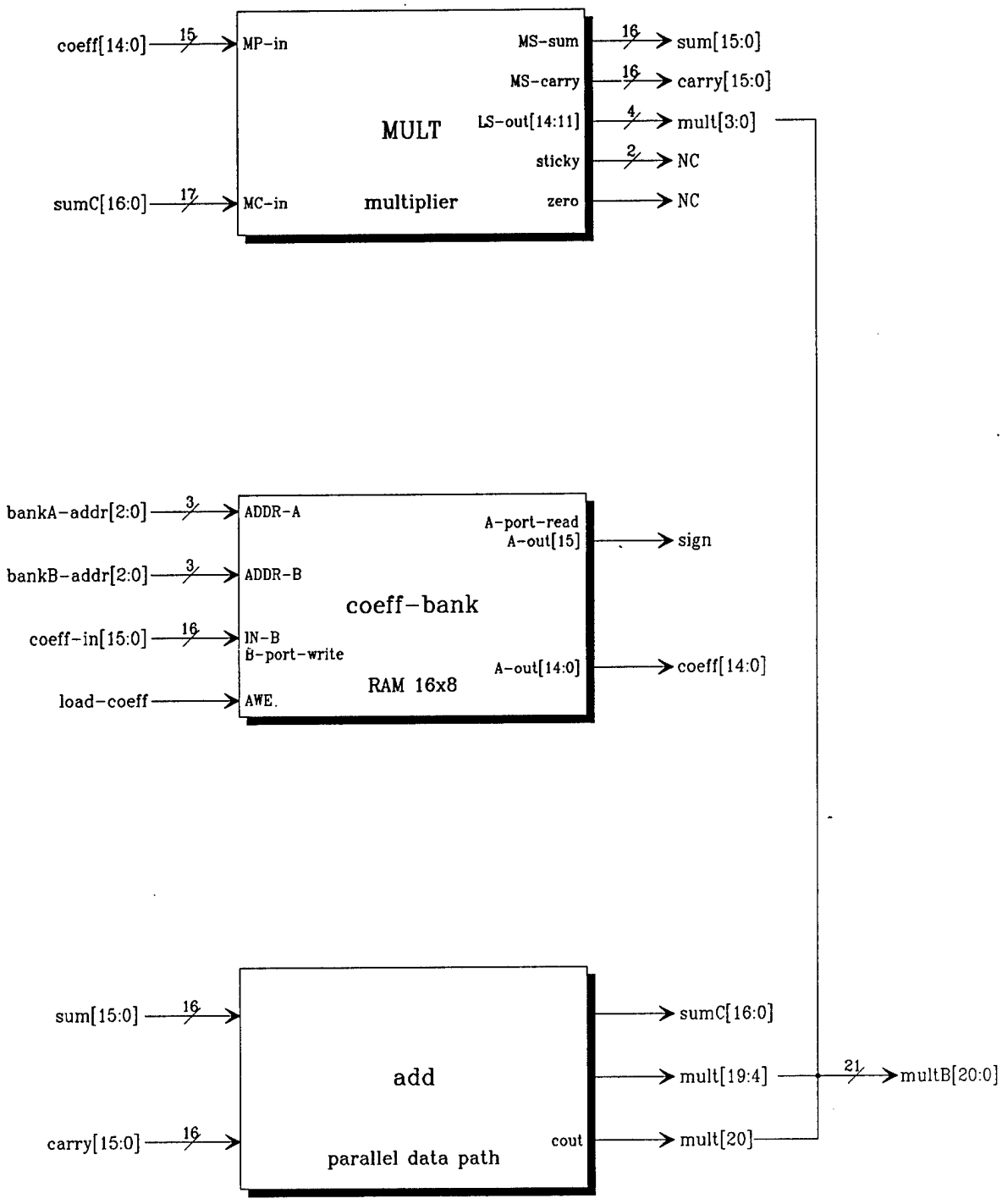


Fig. 5 /SFILTER/MULTC

May 5, 1989

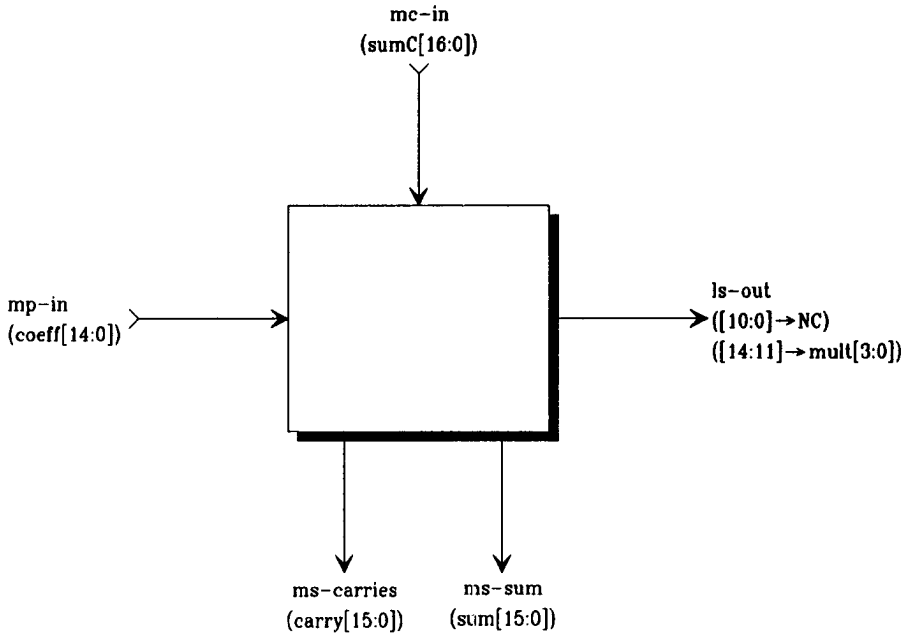


Fig 5A sfilter/multC/mult

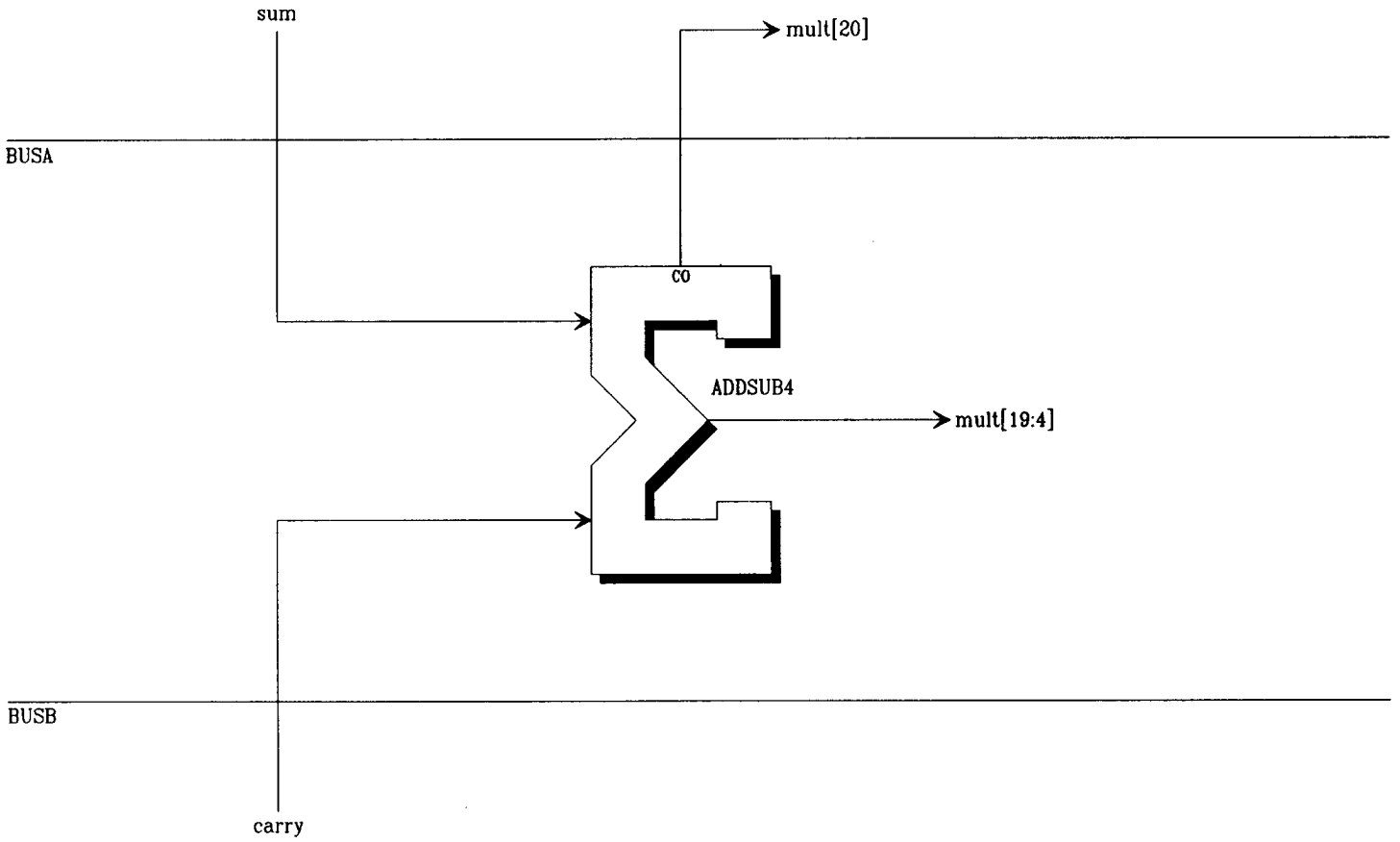


Fig 5B /SFILTER/multC/add

May 5, 1989

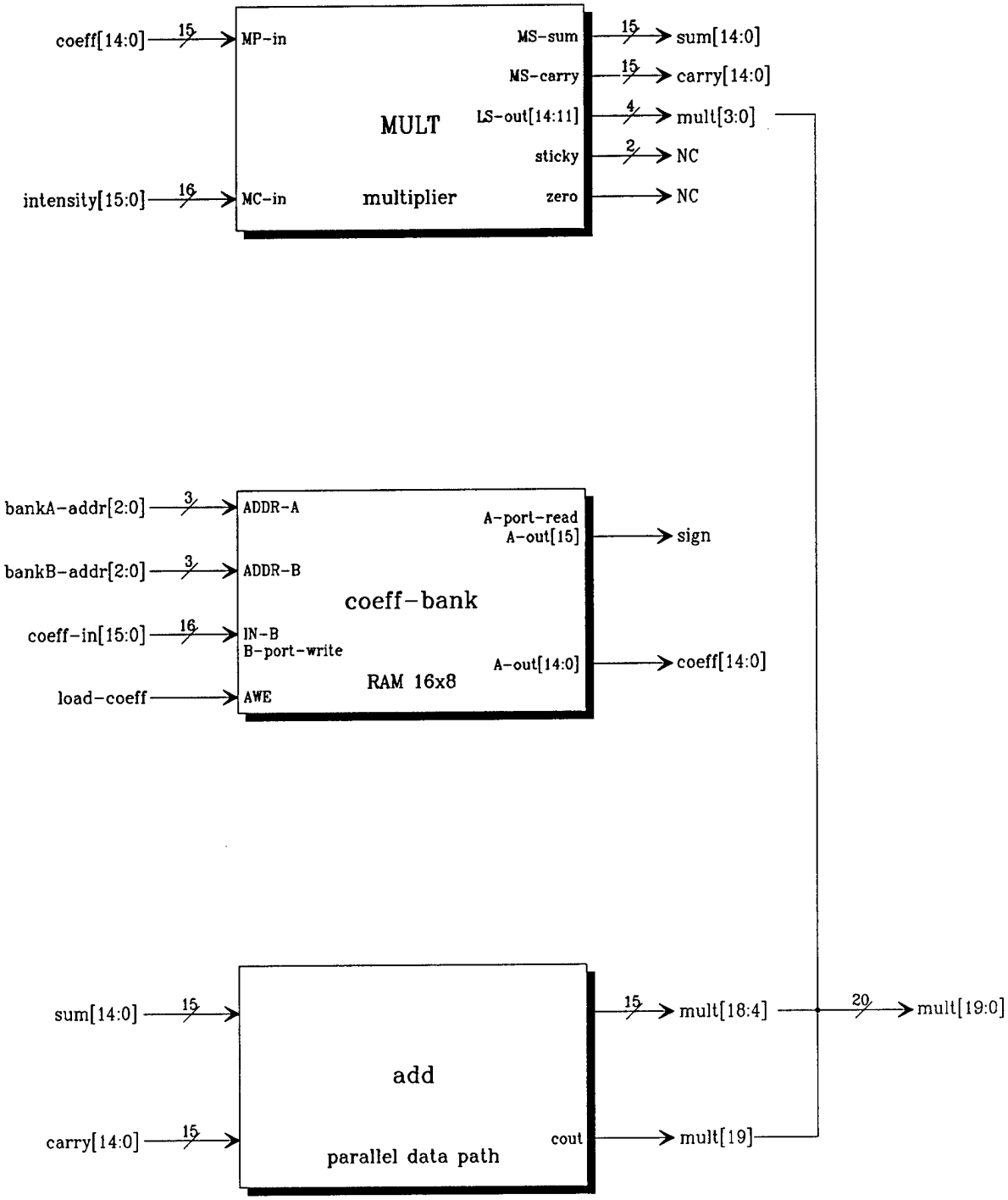


Fig. 6 /SFILTER/MULTD

May 5, 1989

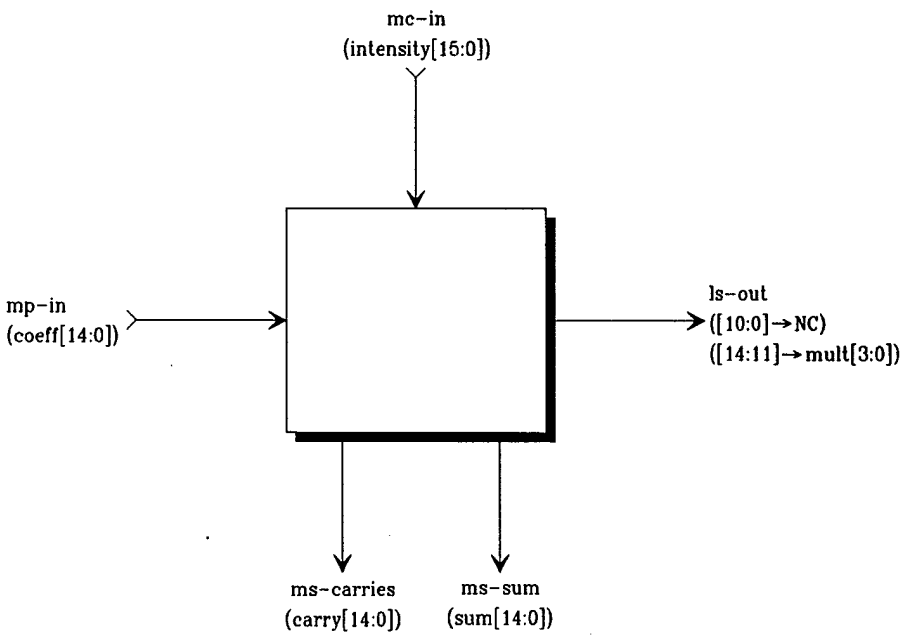


Fig 6A sfilter/multD/mult

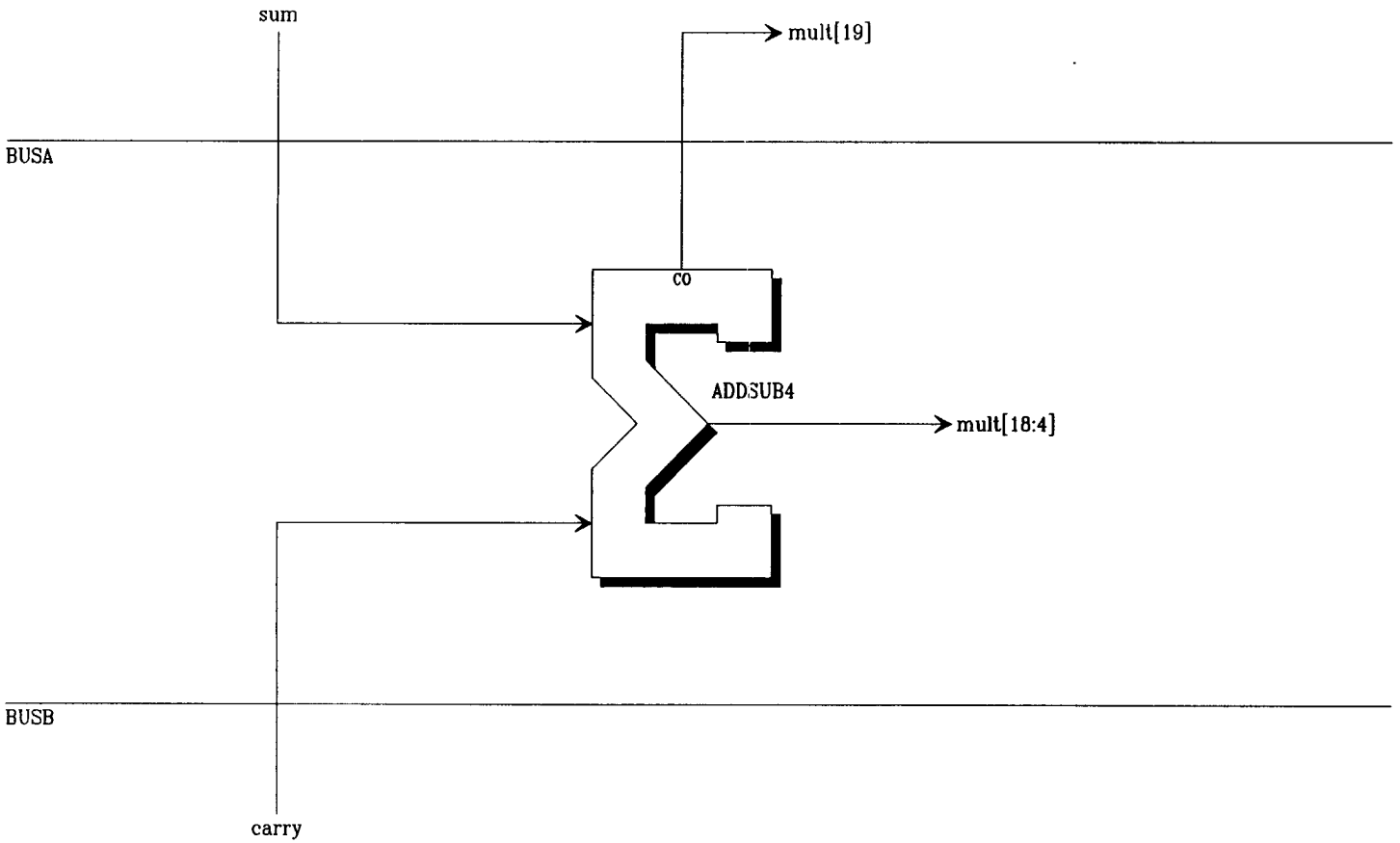


Fig 6B /SFILTER/multD/add

May 5, 1989

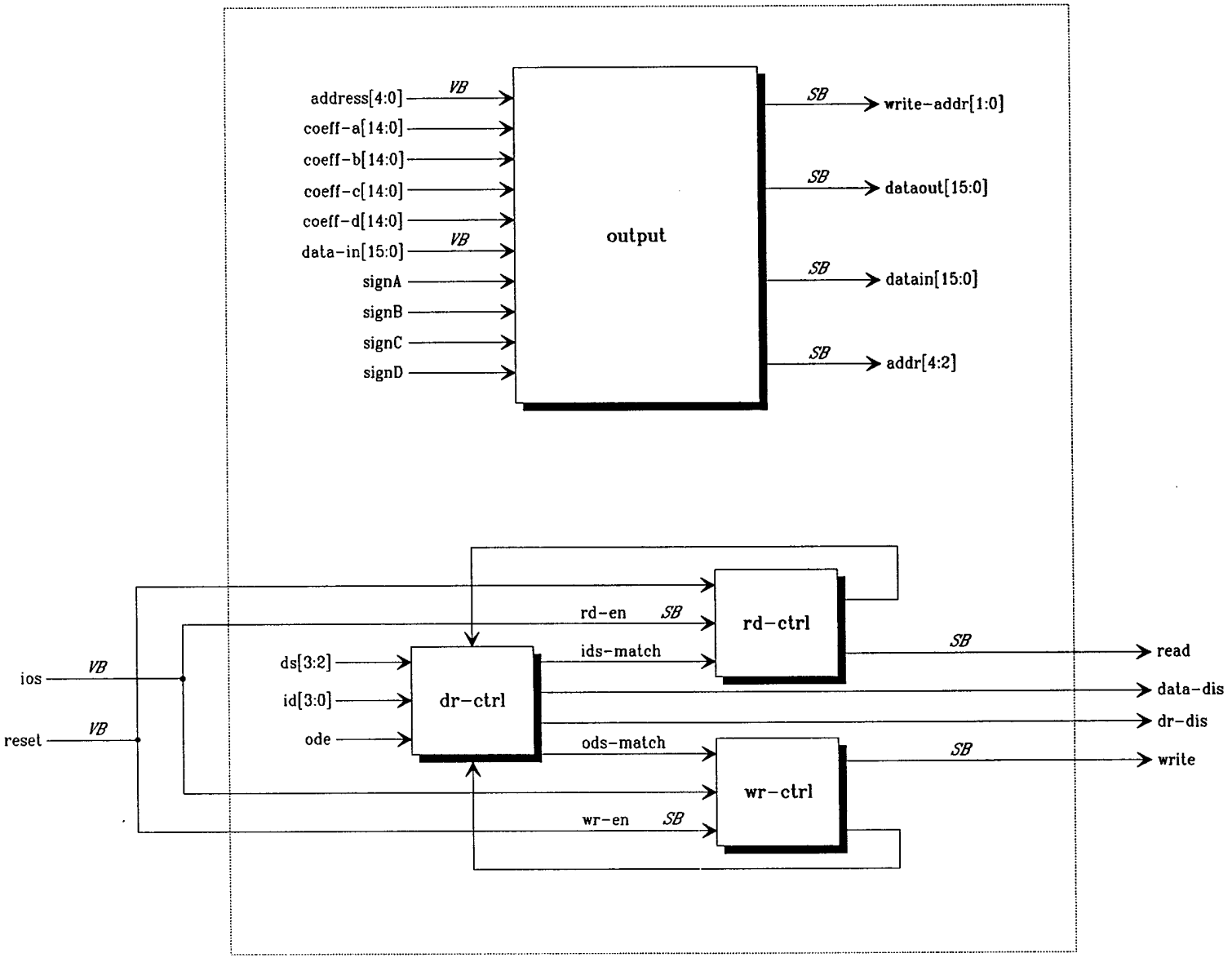
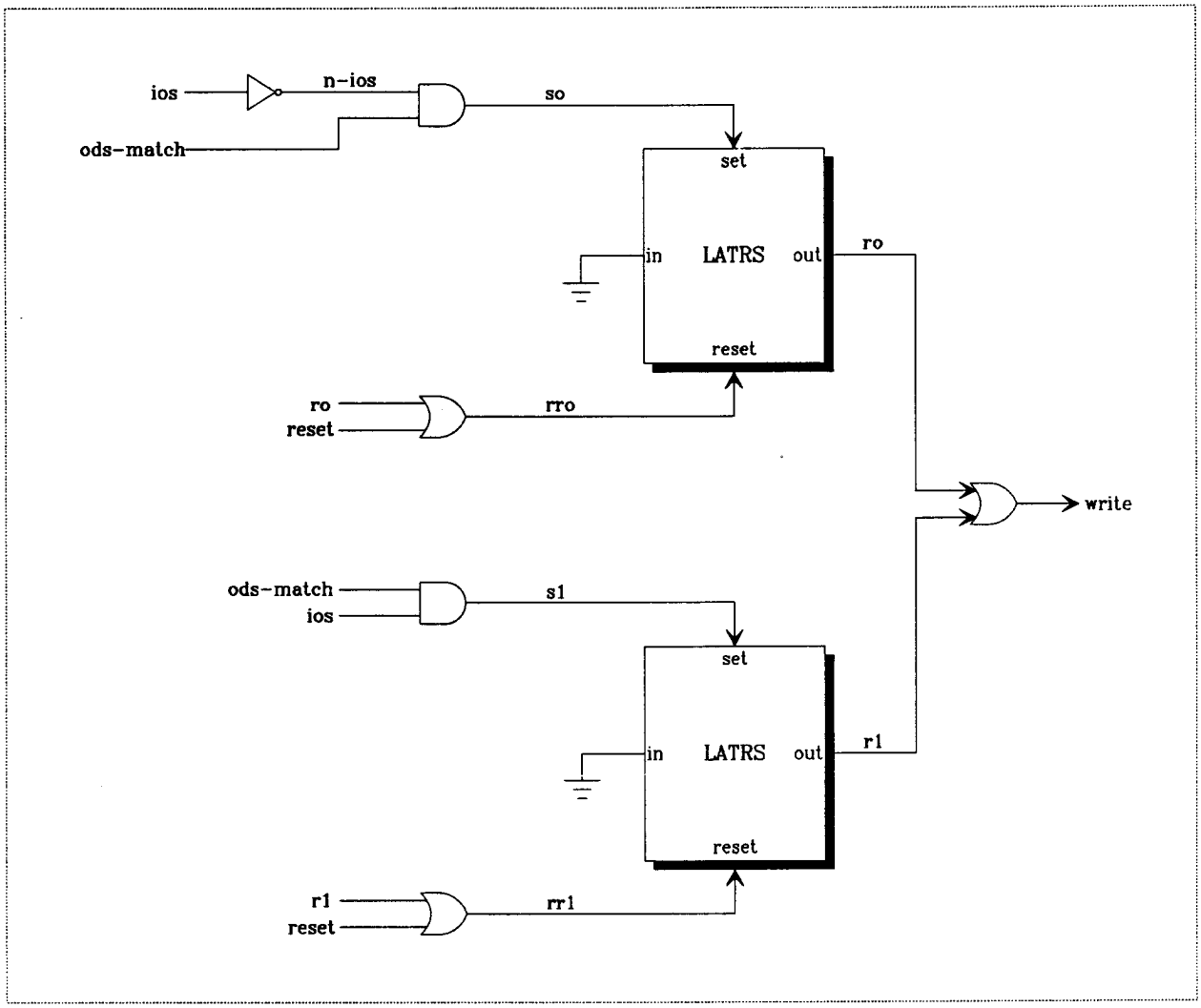


Fig. 8 /SFILTER/HOST-INTERFACE



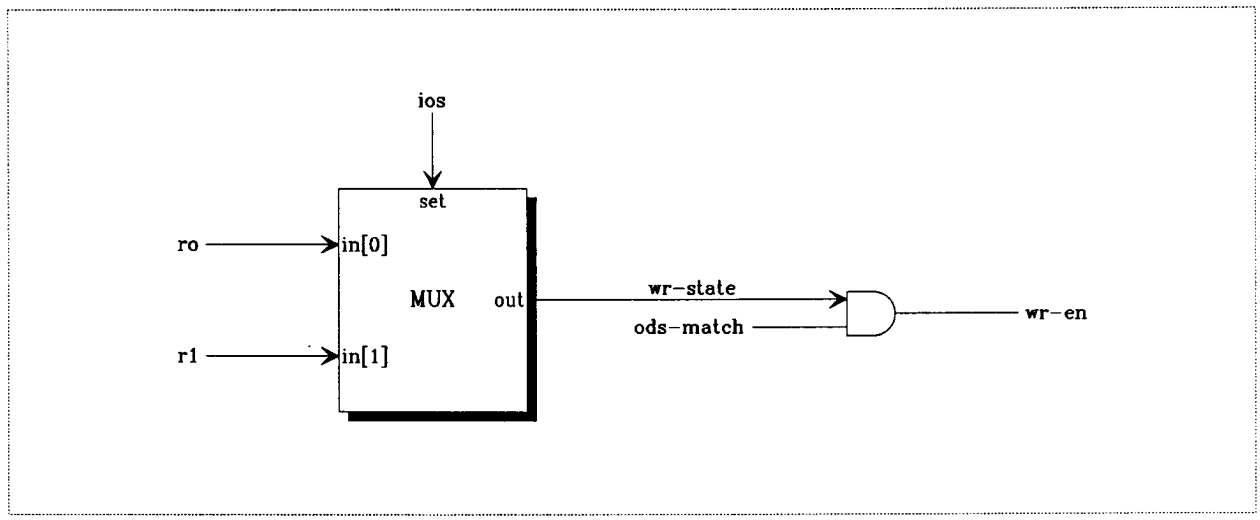
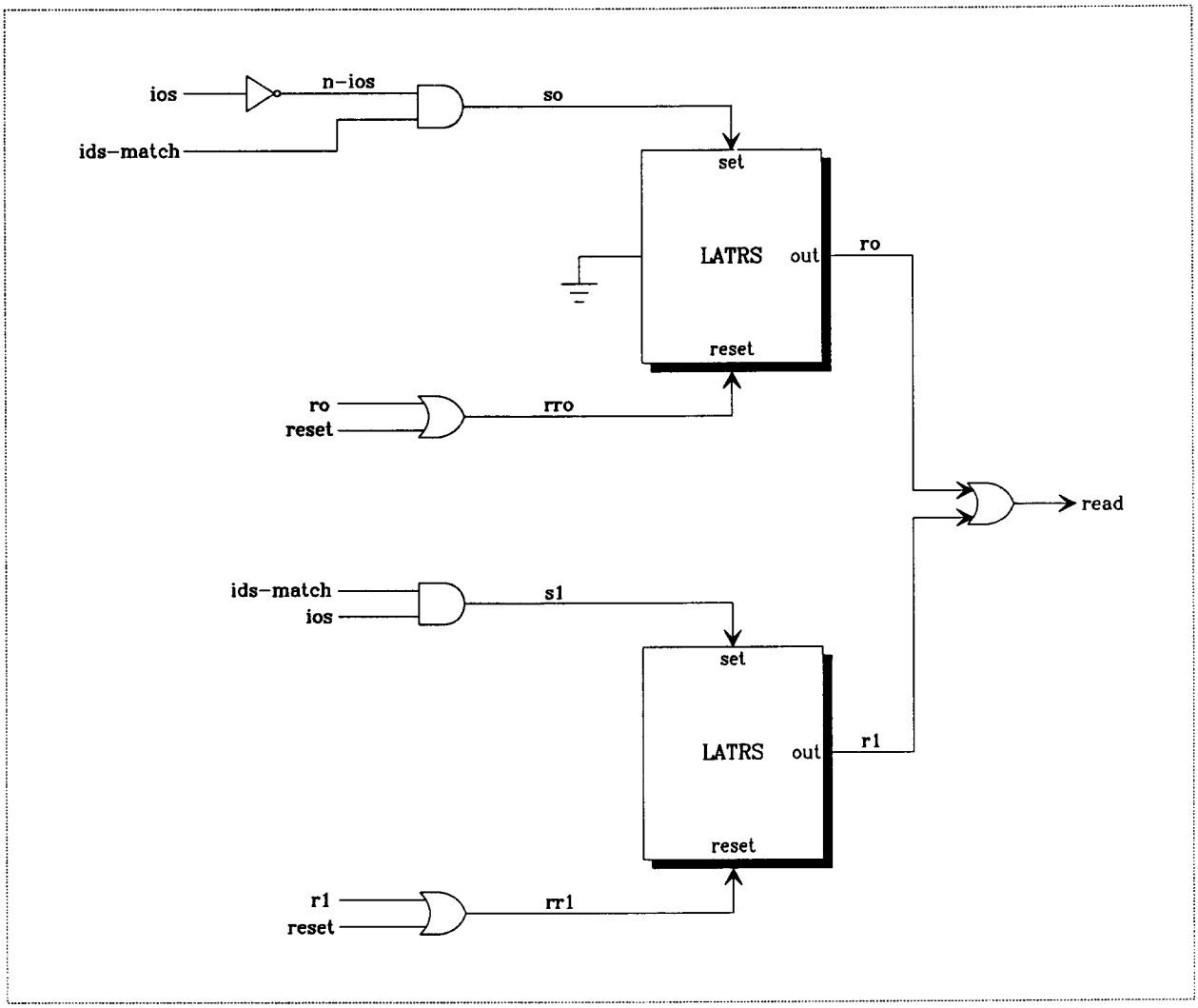


Fig 8A sfilter/host-interface/wr-ctrl



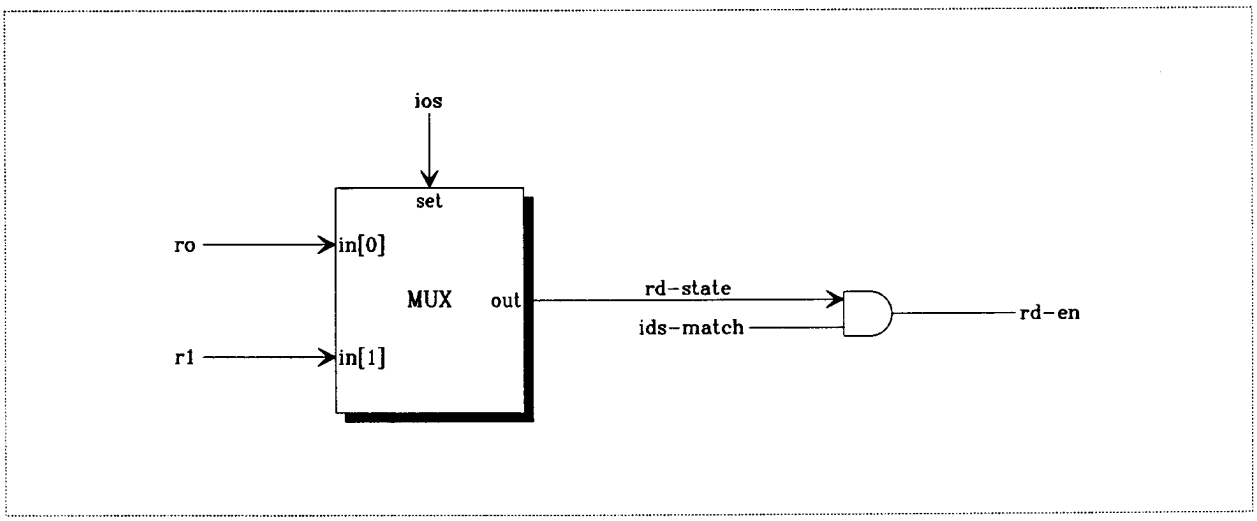


Fig 8B sfilter/host-interface/rd-ctrl

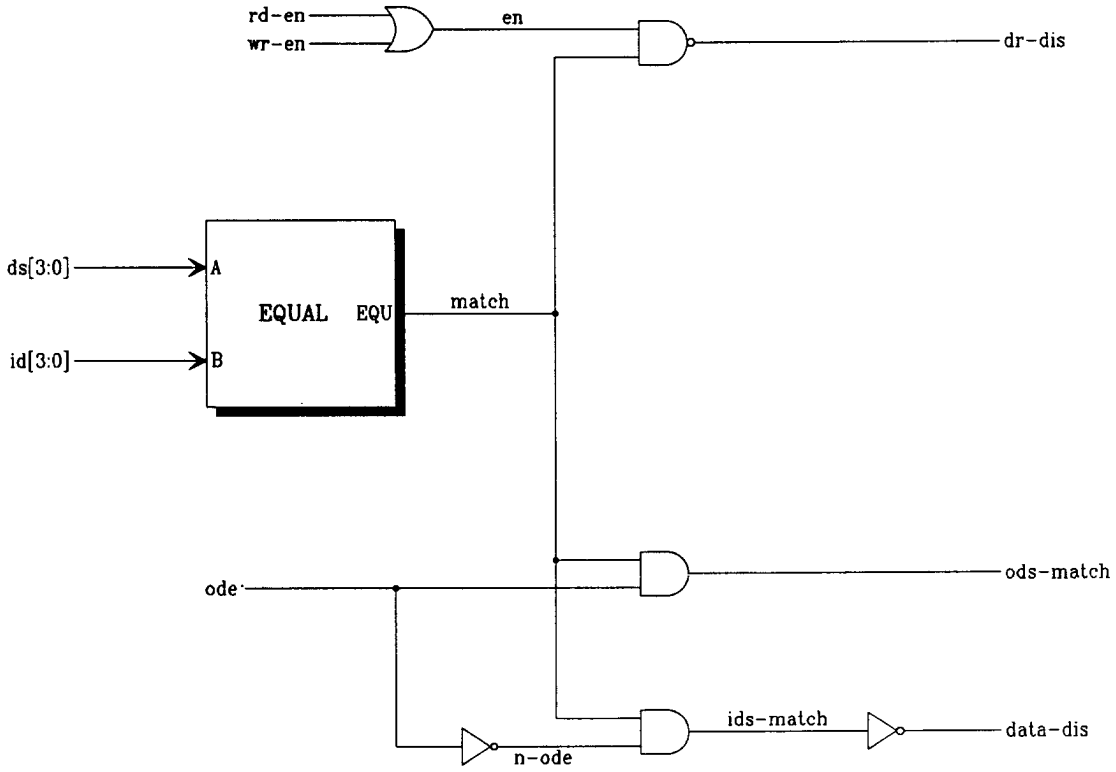
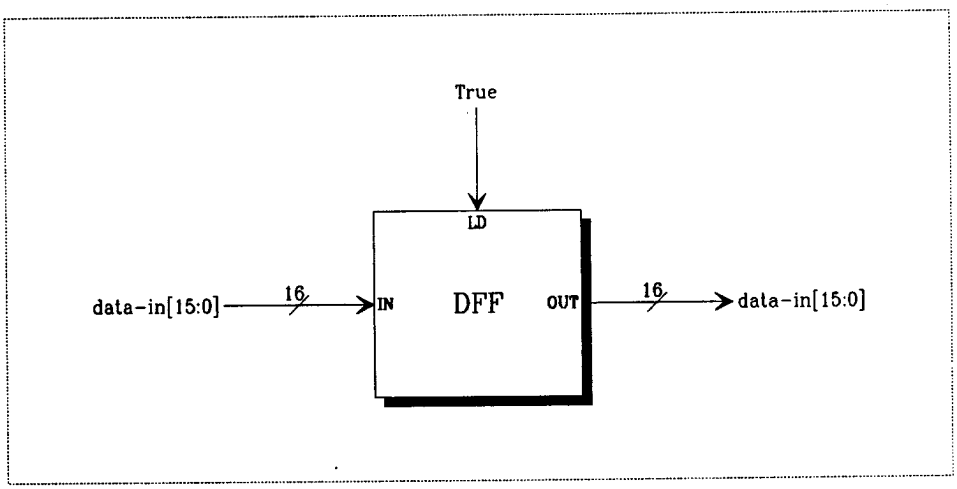
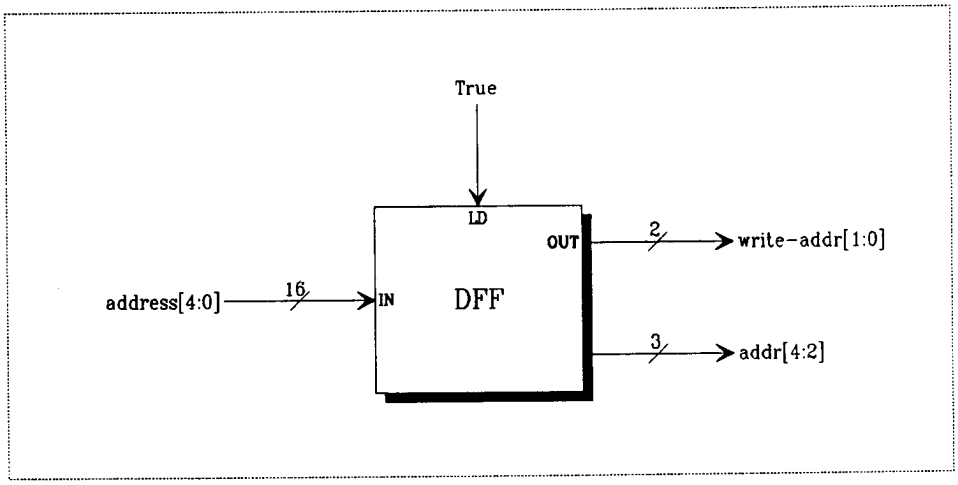


Fig 8C sfilter/host-interface/dr-ctrl





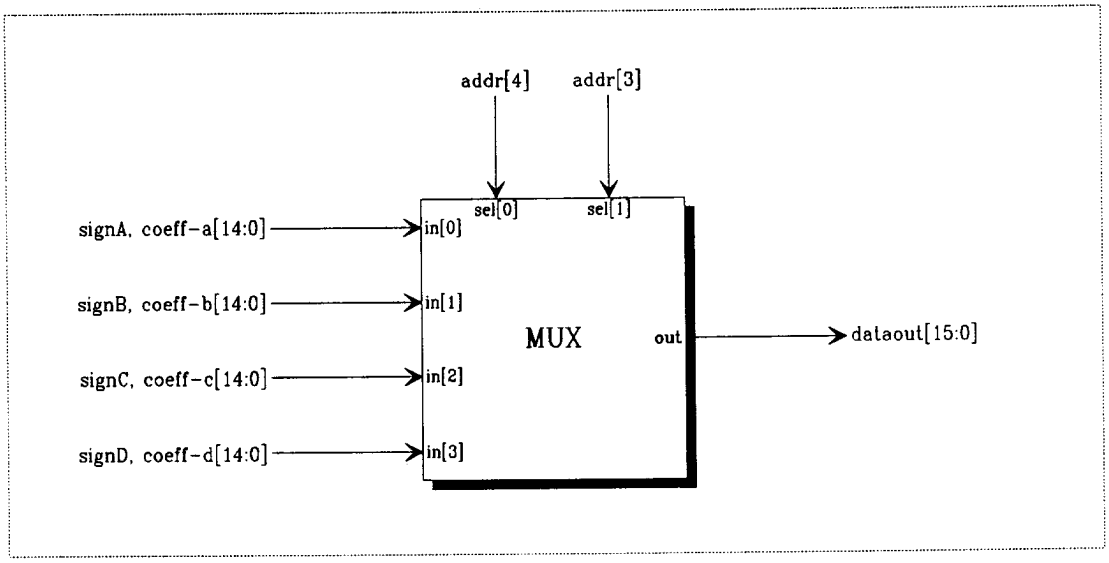
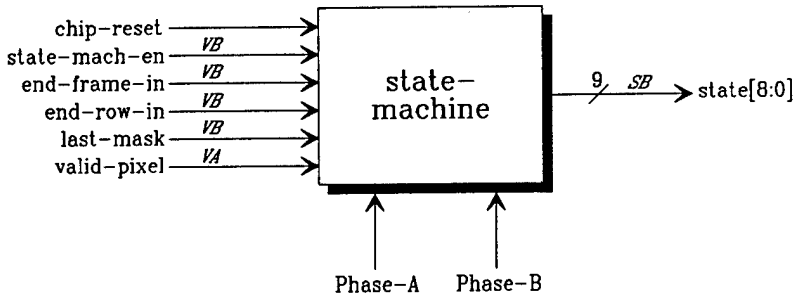
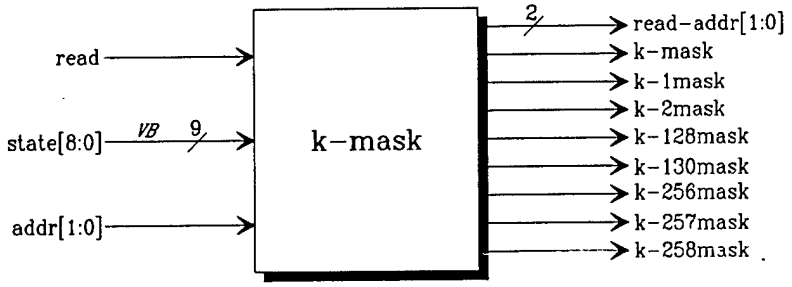


Fig 8b sfilter/host-interface/output





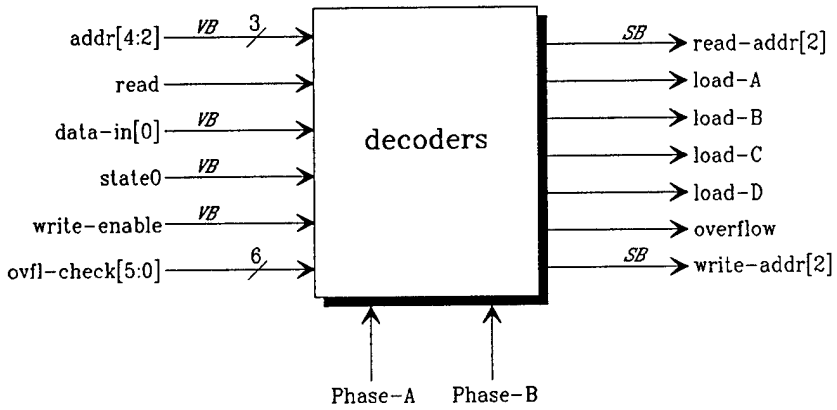
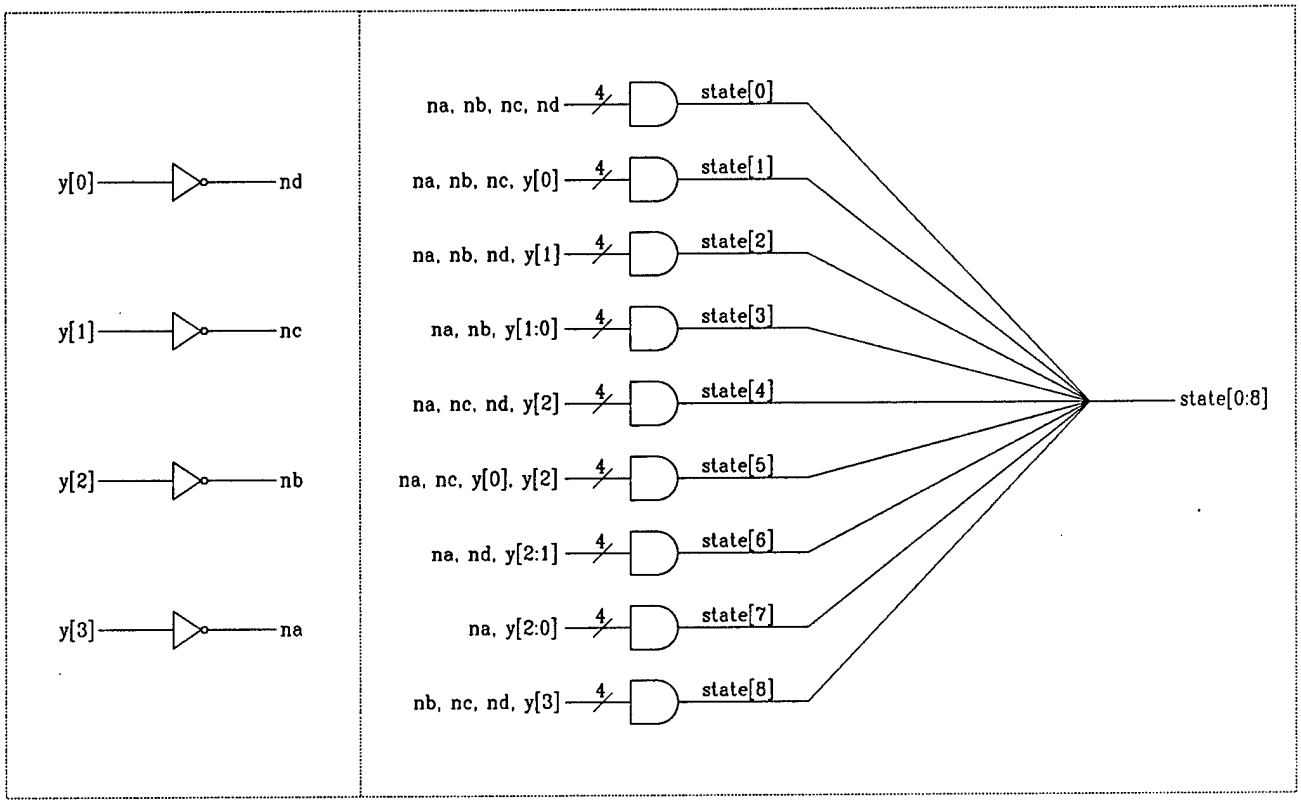
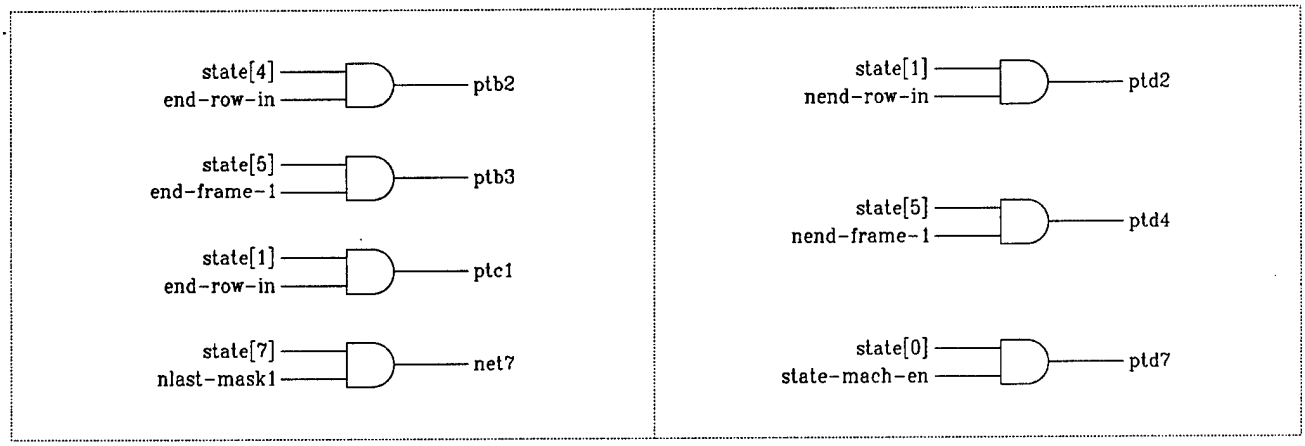
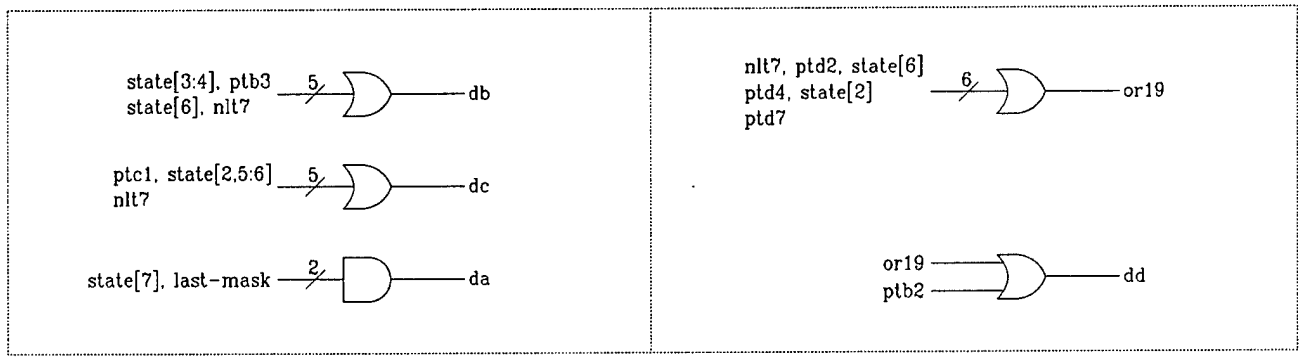


Fig. 9 /SFILTER/CONTROL

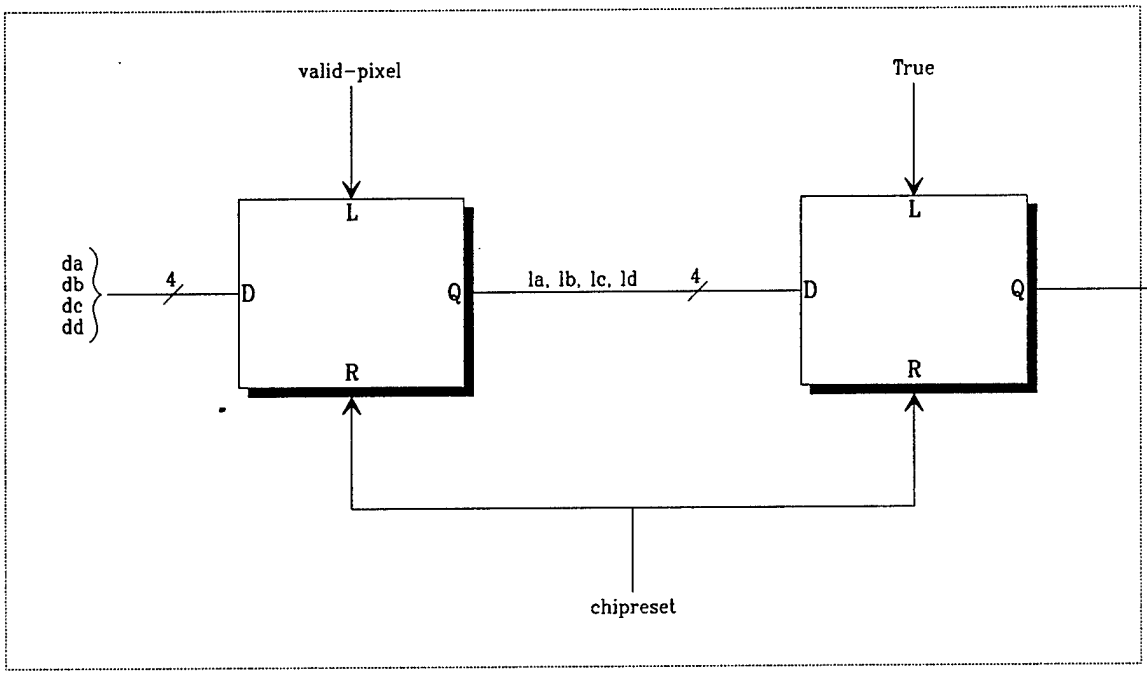
May 4, 1989

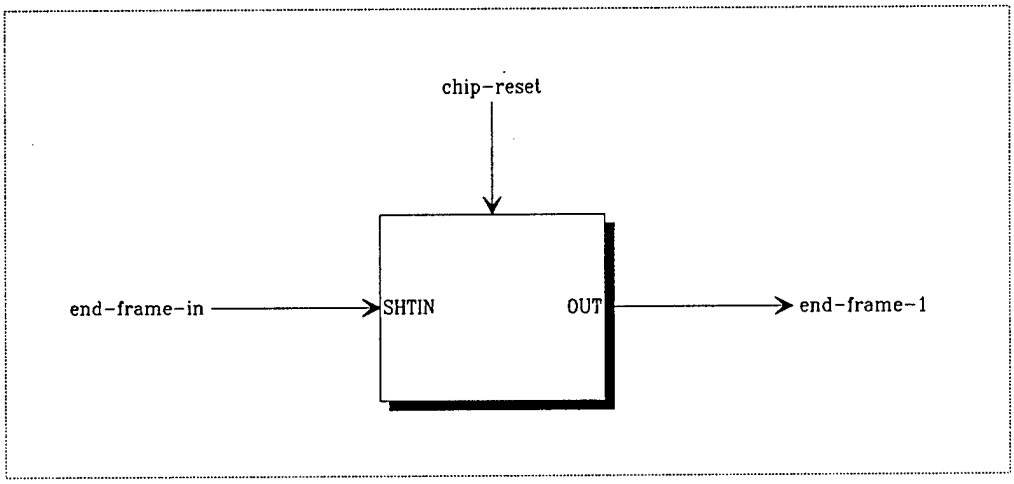


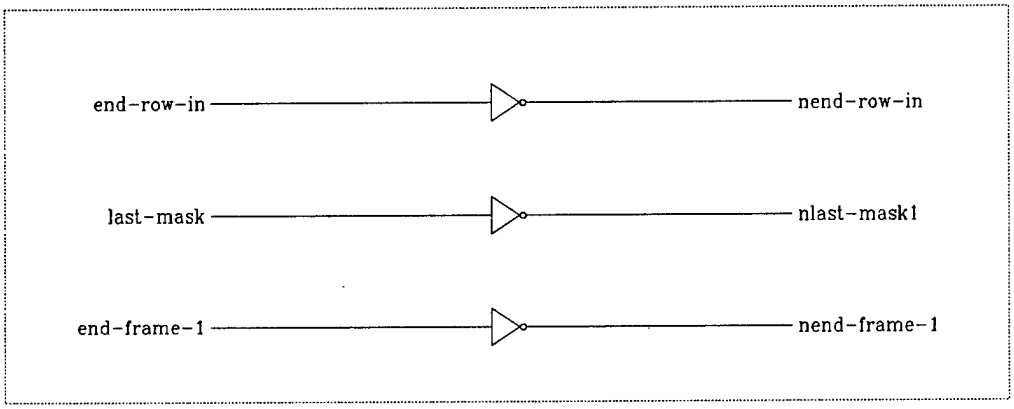




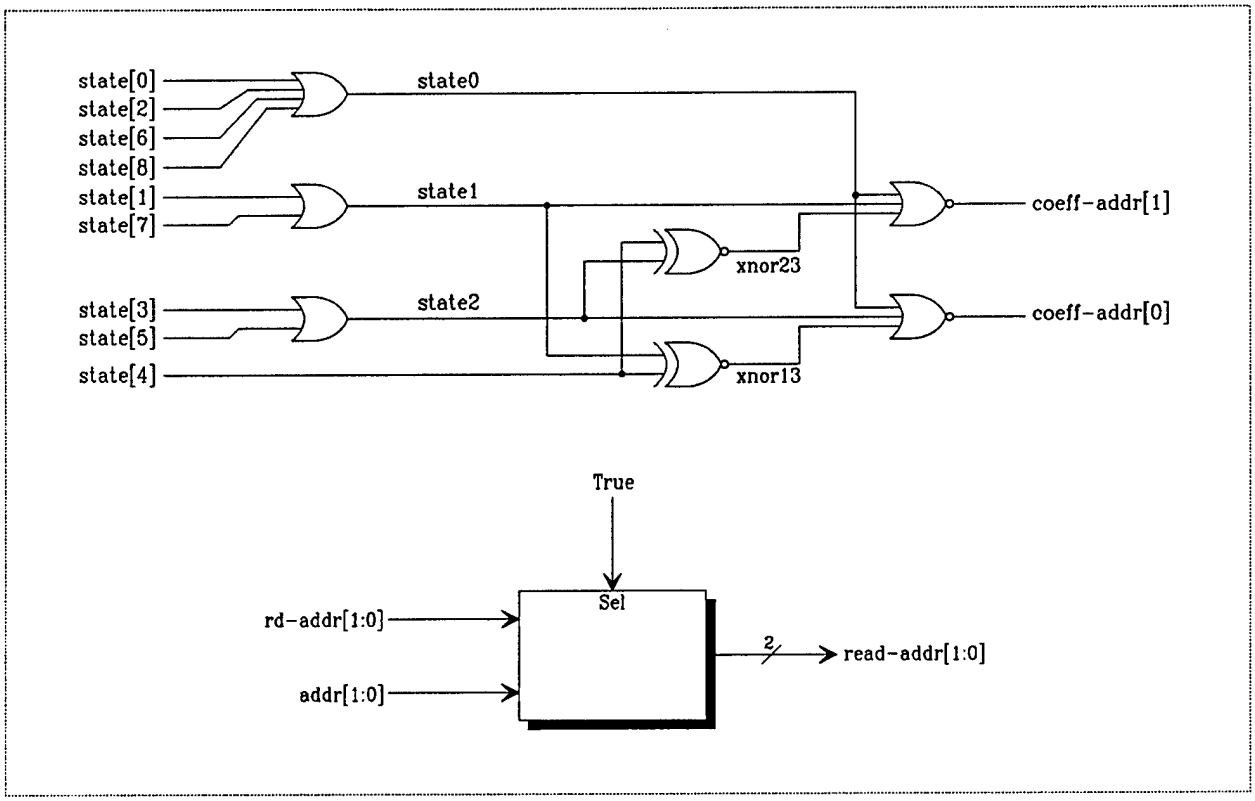
sfilter/control/state-machine

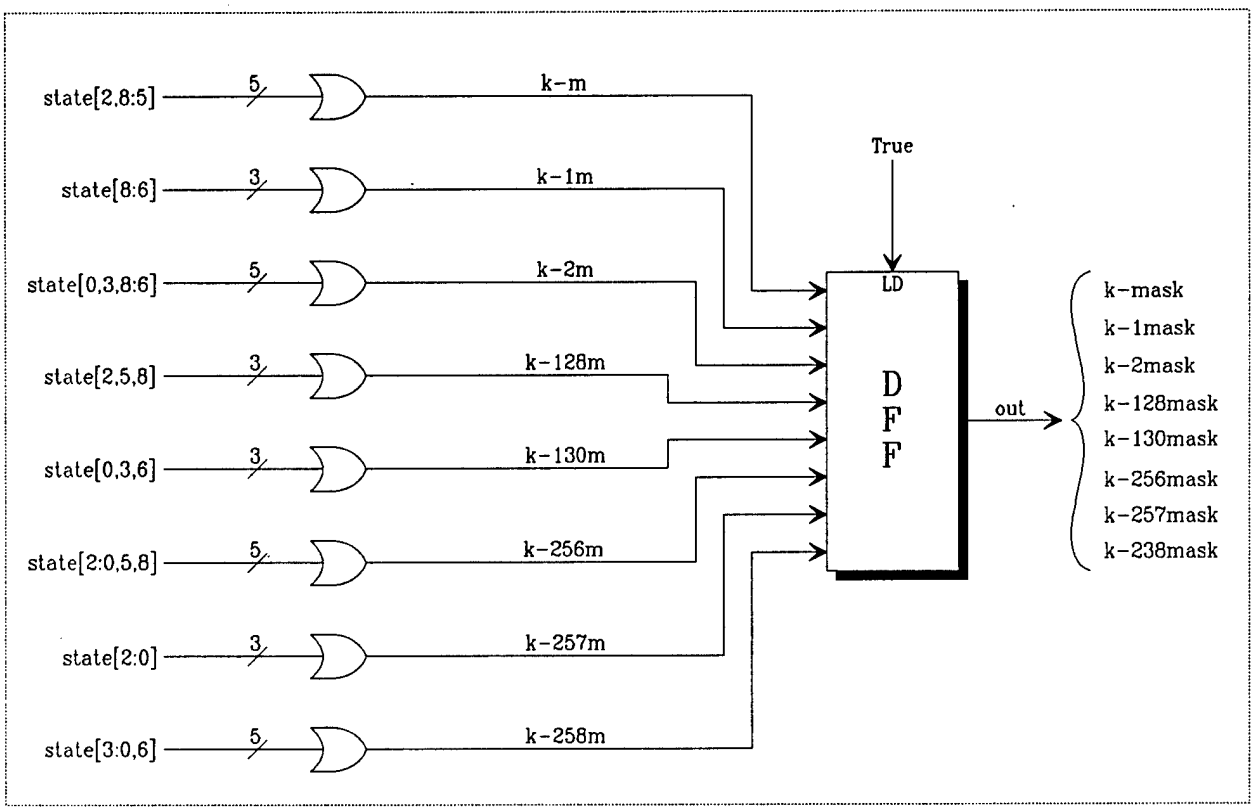






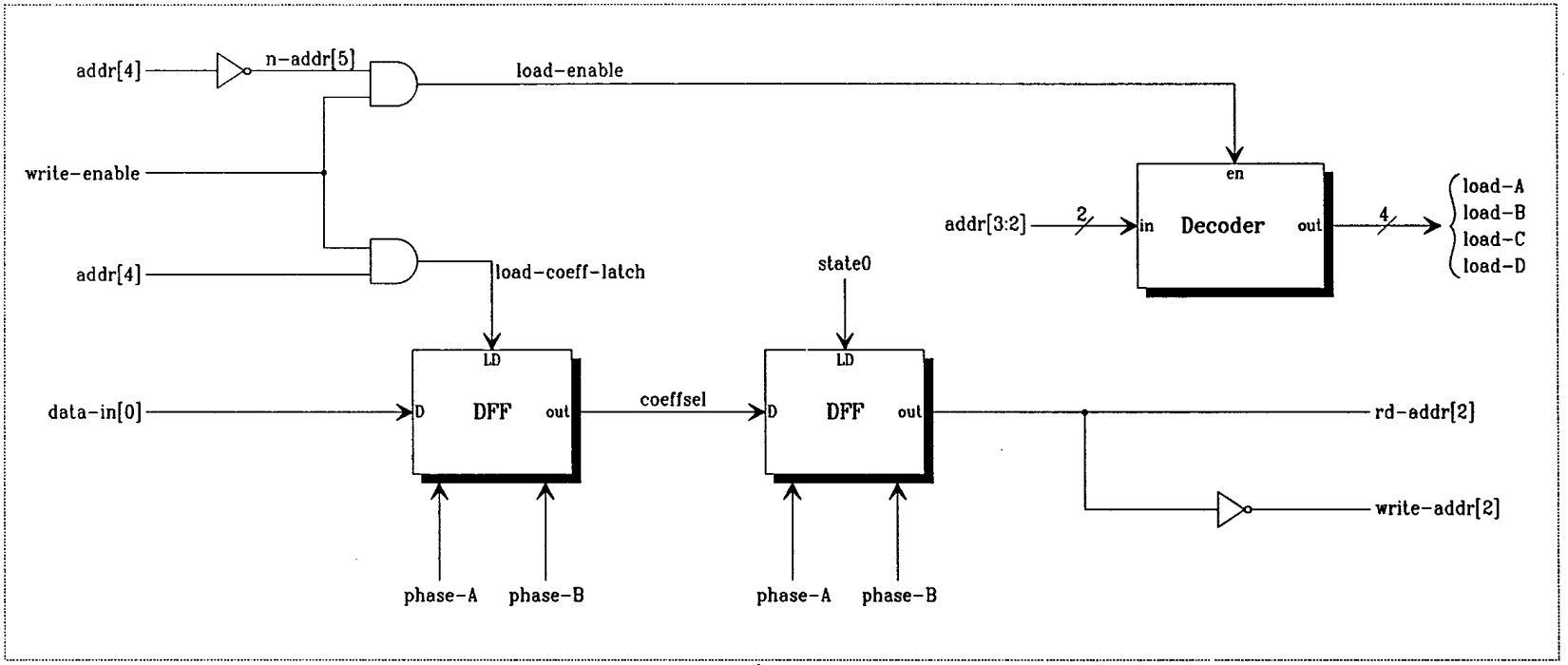
sfilter/control/state-machine

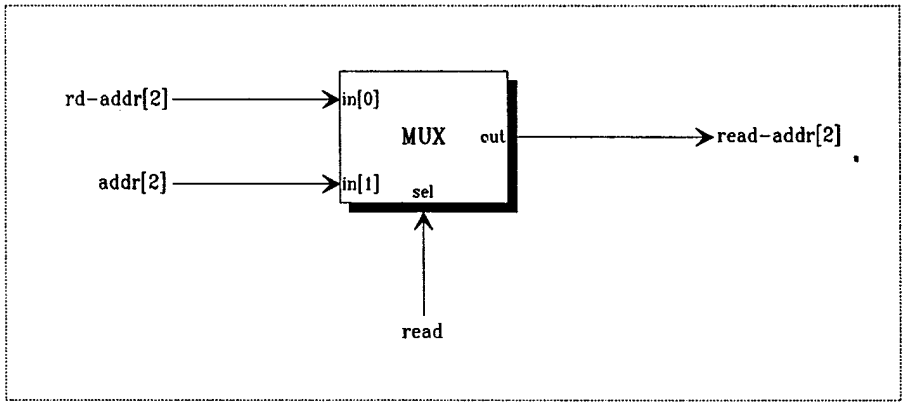




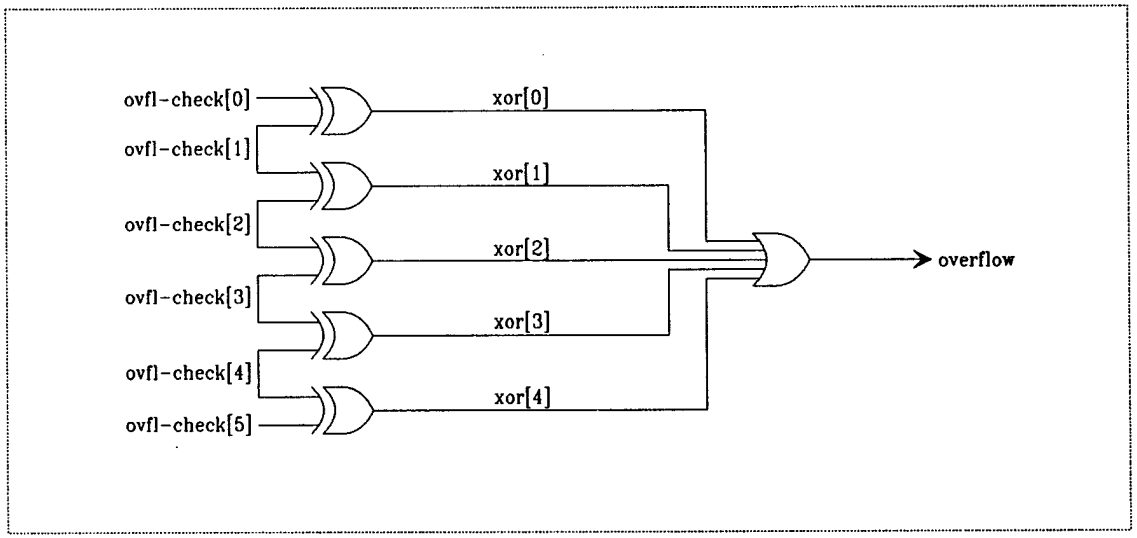
sfilter/control/k-mask

April 28, 1989



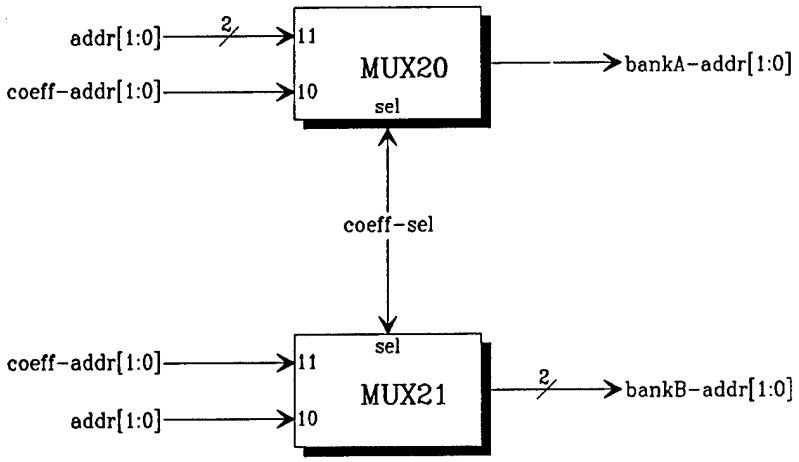


SFILTER/CONTROL/decoders (page 1)

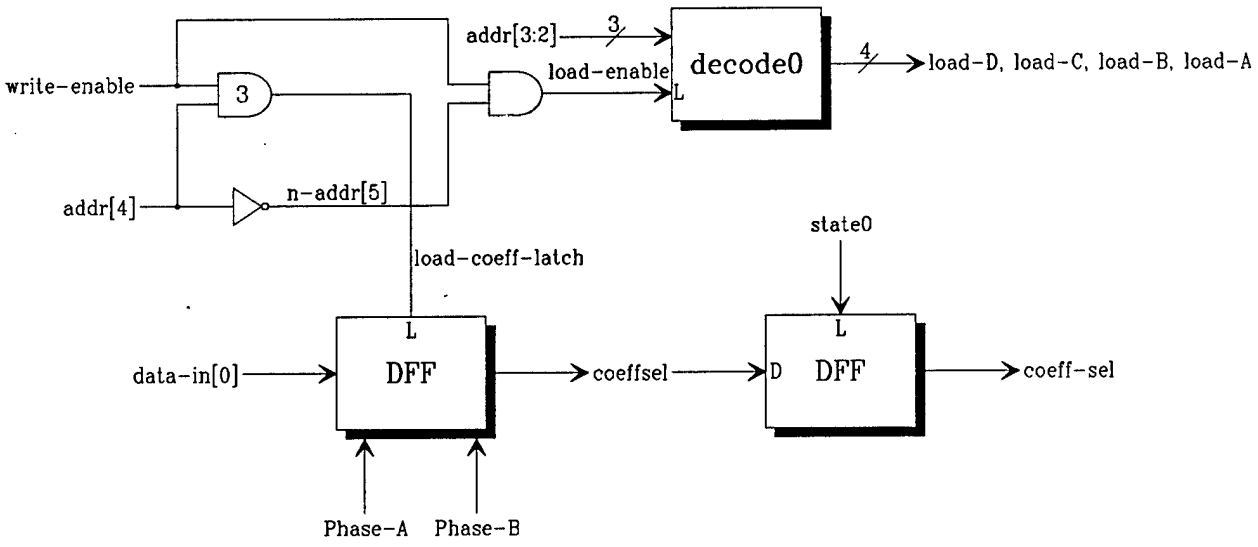


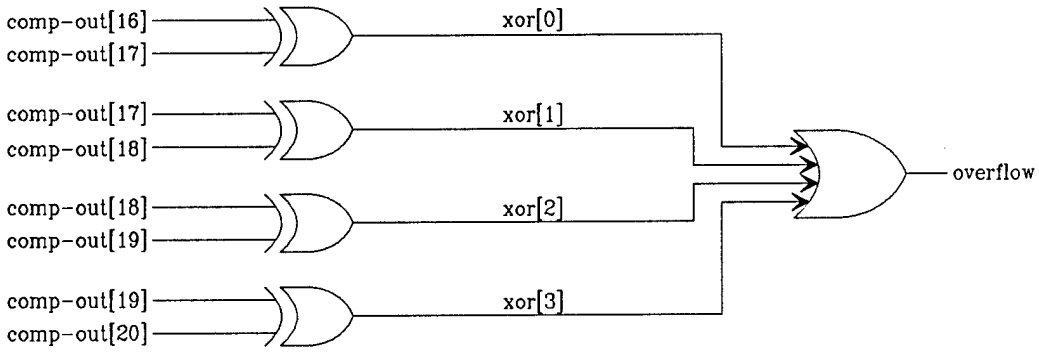
SFILTER/CONTROL/decoders

Address-select

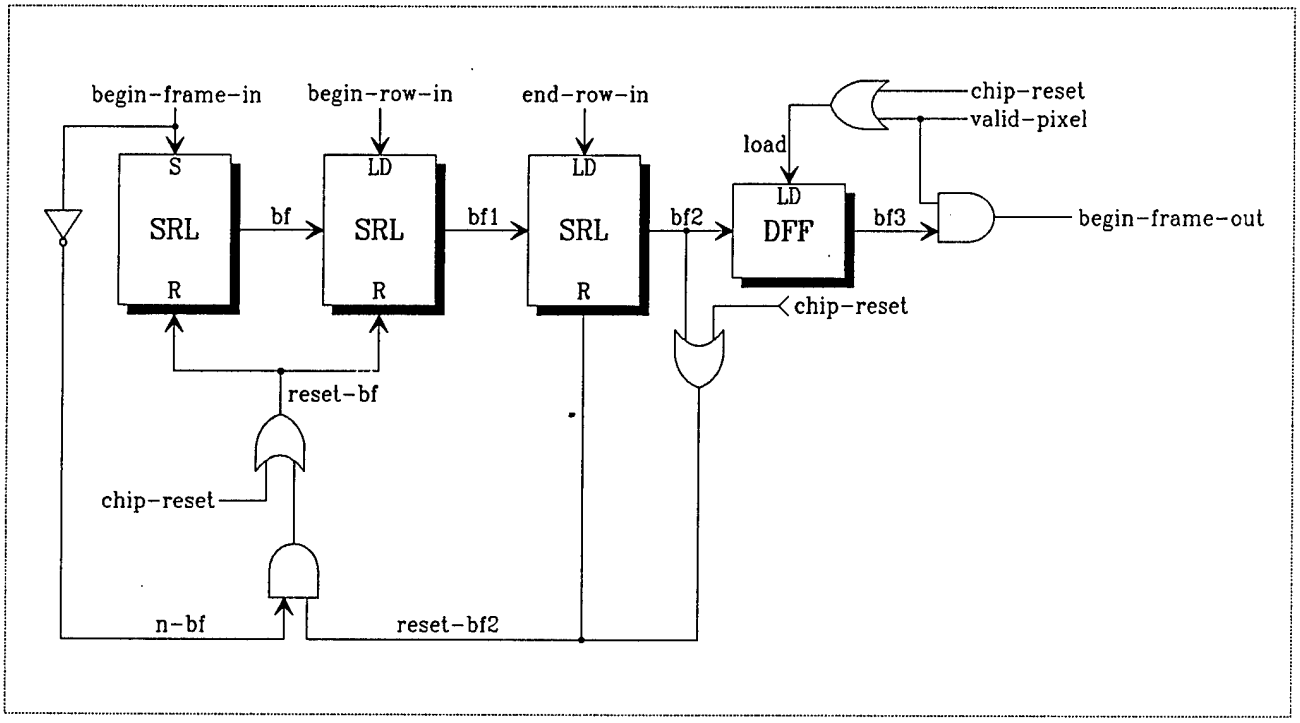


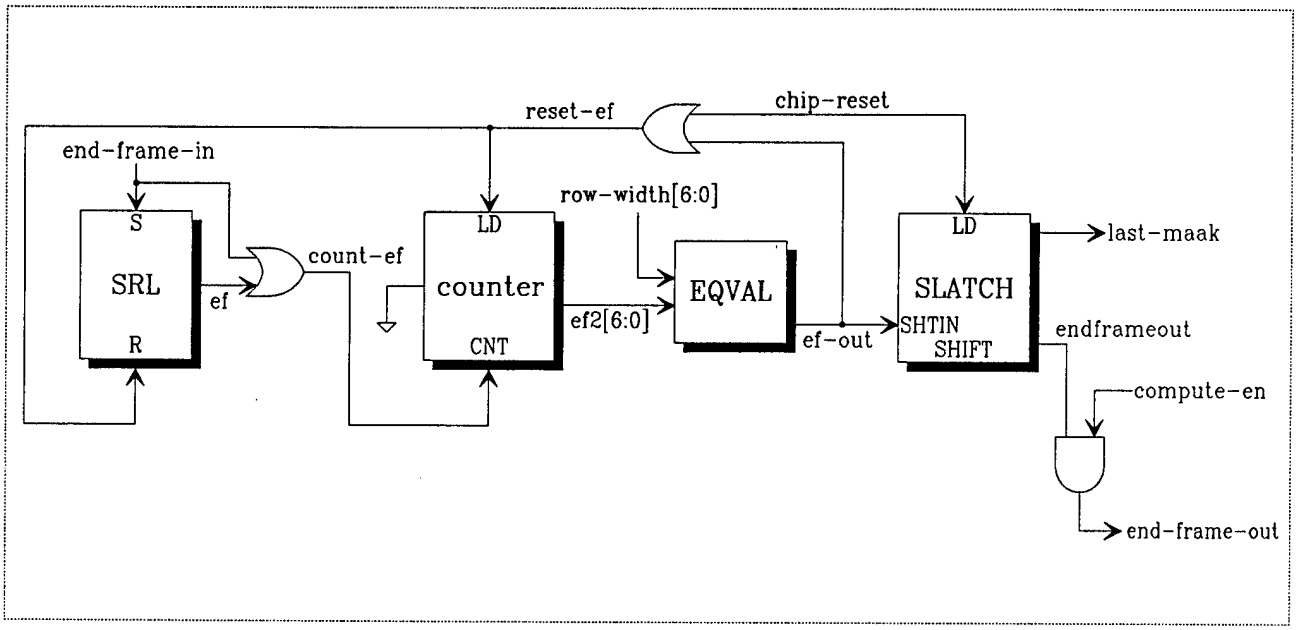
Decoders





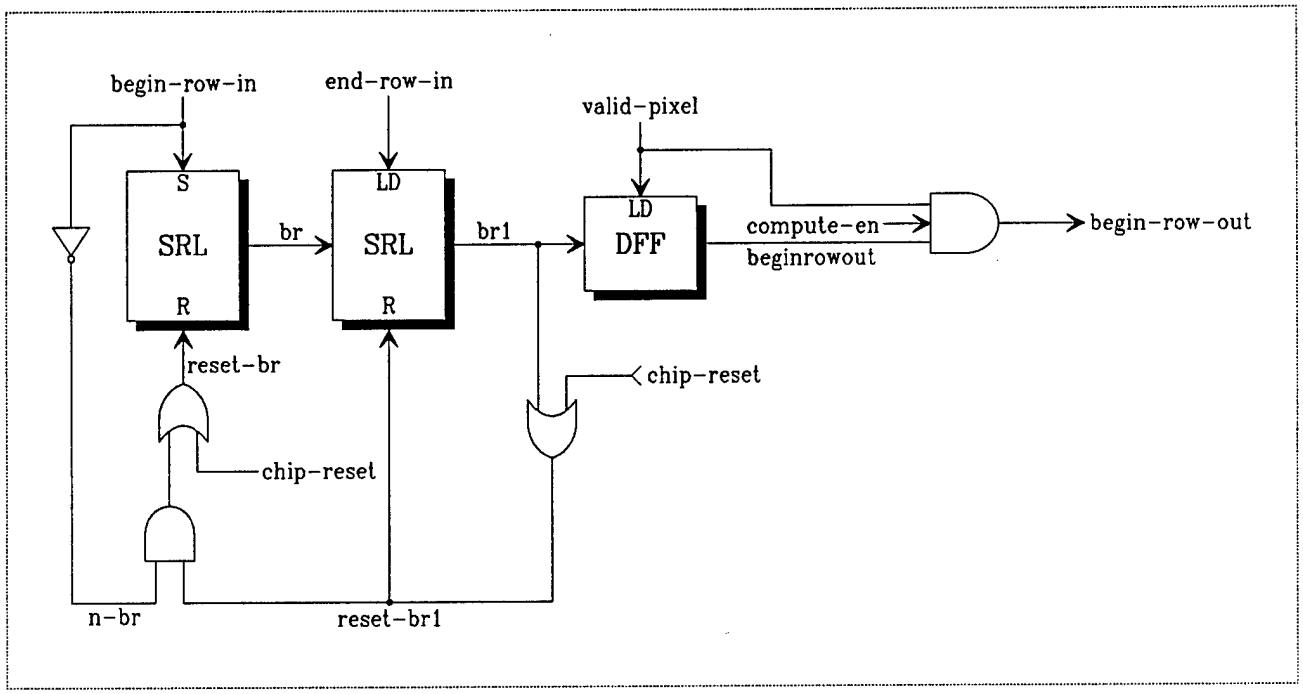
May 4, 1989

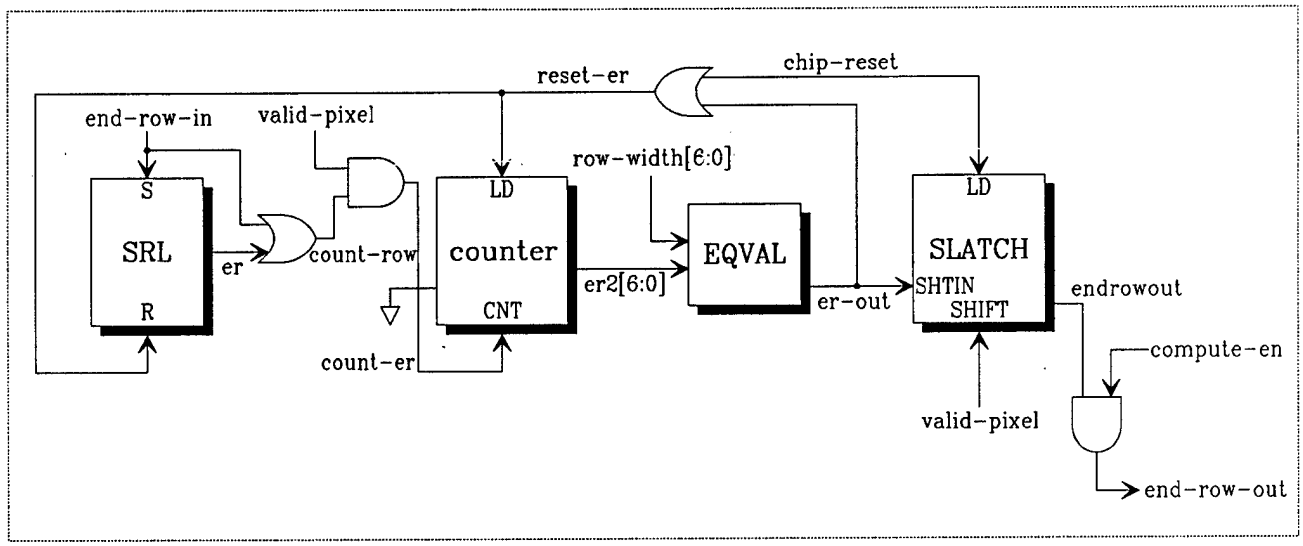


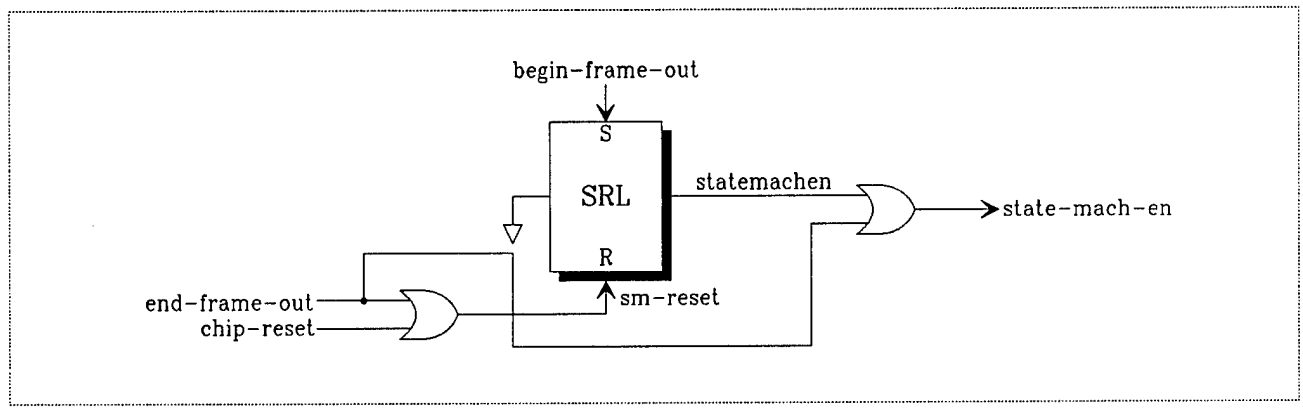


/SFILTER/sp-interface (page 1 of 2)

June 14, 1989







/SFILTER/sp-interface (page 2 of 2)

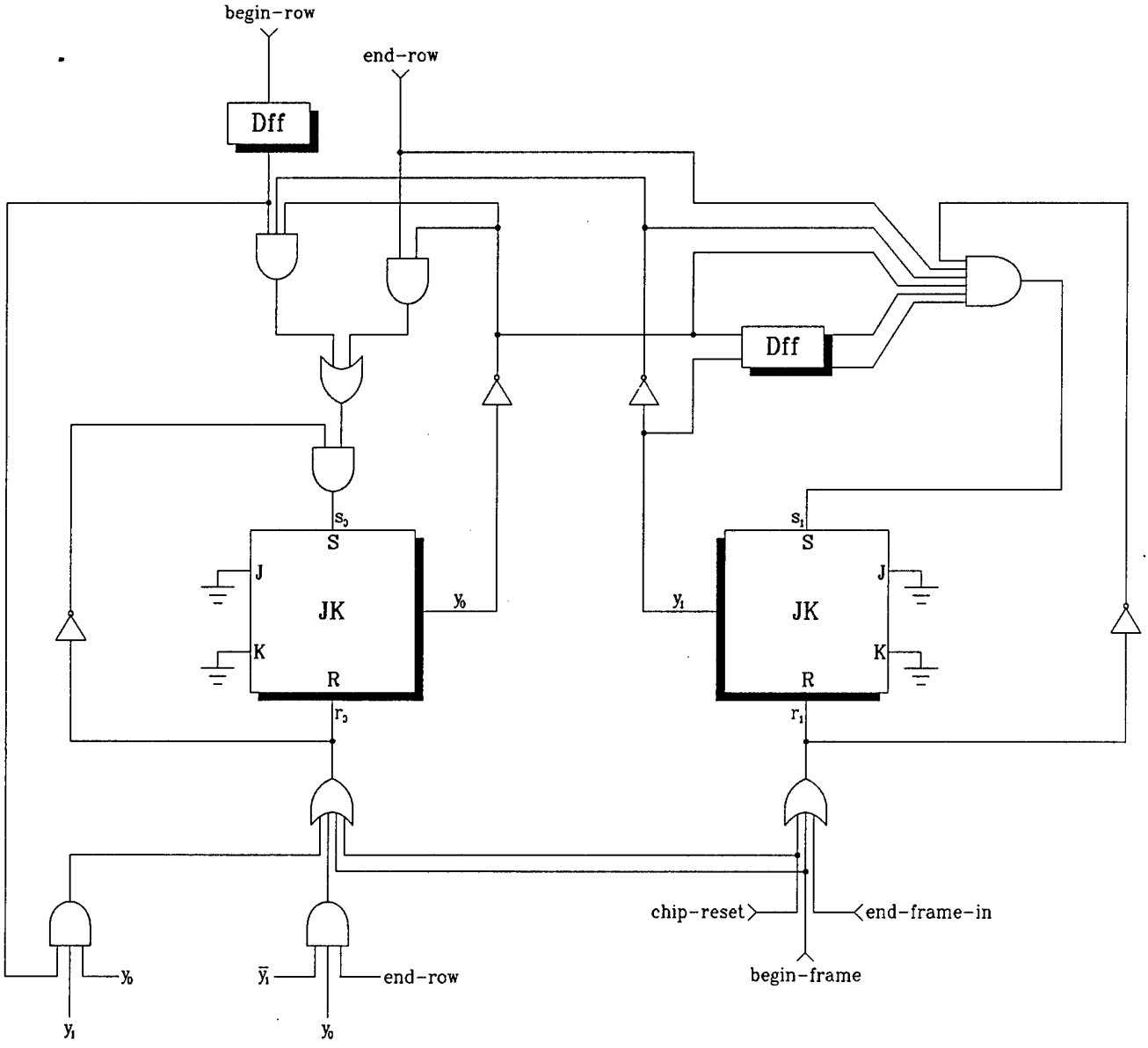
June 14, 1989

$$s_0 = (\bar{y}_1 \bar{y}_0 b_{r_{k-1}} + \bar{y}_0 e\ )\ \text{reset}$$

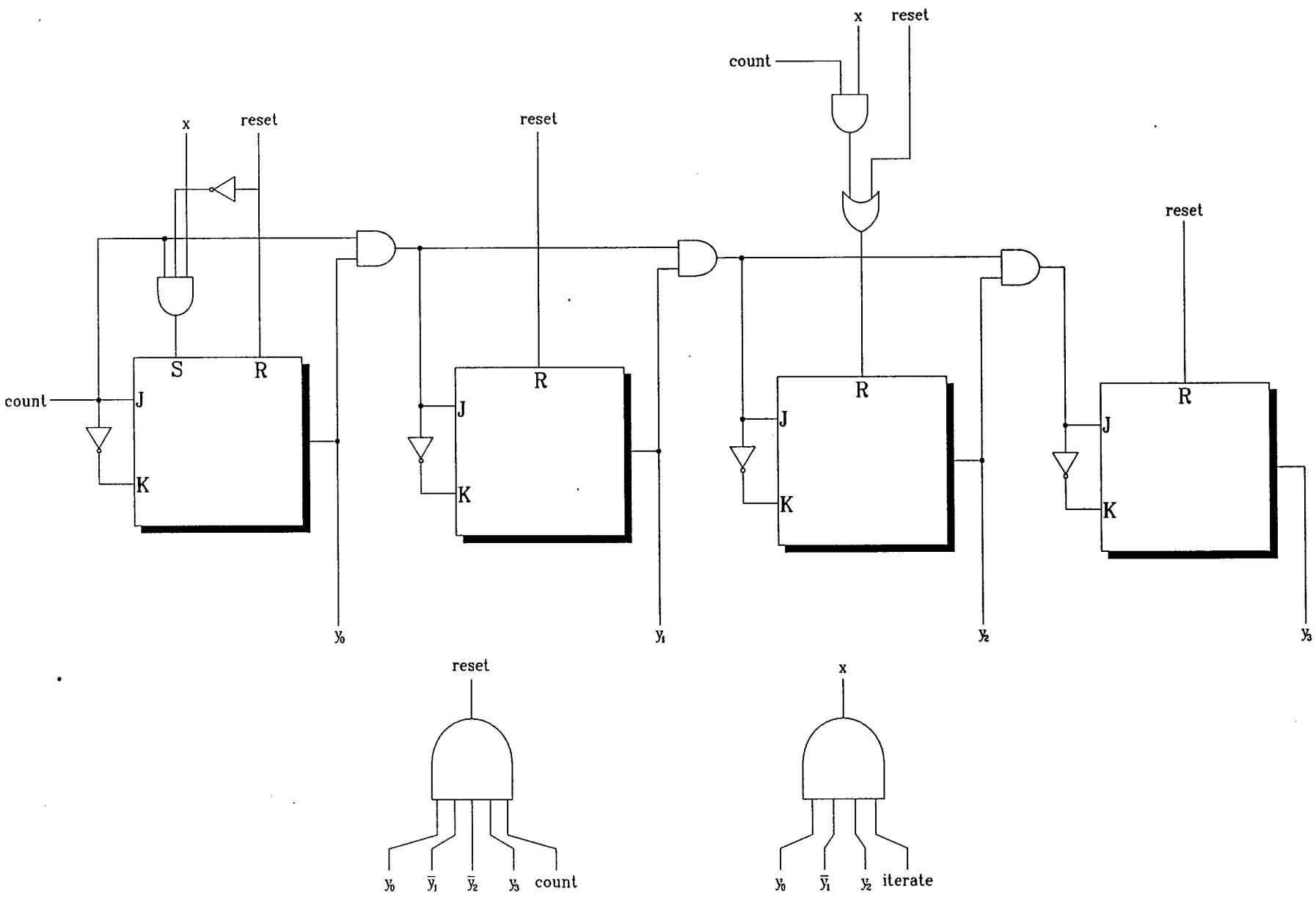
$$r_0 = \text{reset} + b_f + y_1 y_0 b_{r_{k-1}} + \bar{y}_1 y_0 e_r$$

$$s_1 = r_1 \hat{}\{(y_1 \bar{y}_0)_{k-1} (\bar{y}_1 \bar{y}_0)_k e_r\}$$

$$r = \text{reset} + b + \text{end-frame-in (last-row)}$$



Schematic of state-mach block



Schematic of state-mach

```
INFO:Selecting last corner used - 'GUARANTEED'
Operating condition changed: 60 deg C and 5.00v


  CLOCKS
Phase 1 High =    75.8ns    Phase 2 High =  117.5 ns
Cycle (Ph1) =   114.7ns      Cycle (Ph2) =   142.6ns
Minimum Cycle Time =   193.3ns      Symmetric Cycle Time =   234.9ns

 ** Minimum Phase 1 High Time =    75.8 ns (clockdelay:9.1ns (84.9-75.8))
pipe/mem1/fifo1/(internal)      fall       84.9
pipe/mem1/fifo1/read_fifo1      rise       74.6
pipe/control/logic/read_fifo1     rise       74.5
pipe/control/logic/read_fifo1'     rise       63.5
pipe/control/logic/GB.LP.I_220     fall       62.9
pipe/control/logic/read_fifo2     rise       61.8
pipe/control/logic/read_fifo2'     rise       33.6
pipe/control/logic/GB.LP.I_265     fall       31.7
pipe/control/logic/valid_pixel     rise       31.1
<pe/control/logic/valid_pixel'     rise       14.3
pipe/control/logic/GB.LP.I_139     rise       11.6
pipe/control/logic/GB.LP.I_165     fall       11.2
pipe/control/logic/PHASE_A     rise        9.6
    pixelclk/PHASE_A     rise        8.0
          pixel_clk     rise        0.0

 ** Minimum Phase 2 High Time =   117.5 ns (clockdelay:4.6ns (122.1-117.5))
multD/coeff_bank/(internal)      fall      122.1
multD/coeff_bank/A_ADDR[1]     rise     120.7
control/read_addr[1]     rise     120.5
control/read_addr[1]'     rise      56.4
 control/GB.LP.I_248     fall       50.0
        control/read     rise       49.0
 host_interface/read     rise       48.4
host_interface/read'     rise       15.3
host_interface/GB.LP.I_298     fall       14.3
host_interface/GB.LP.I_152     rise       12.8
host_interface/GB.LP.I_161     fall       10.4
host_interface/GB.LP.I_290     rise        9.8
host_interface/GB.LP.I_155     fall        7.8
host_interface/id[2]     fall        5.4
  chip_id[2]/chip_id     fall        5.1
 chip_id[2]/chip_id'     fall        3.6
          Chip_id[2]     fall        0.0


 ** Minimum Cycle (Ph1) Time =   114.7 ns (clockdelay:9.4ns (124.0-114.7))
multB/coeff_bank/225   fall     124.0
*multB/coeff_bank/(internal)   fall      122.1
multB/coeff_bank/A_ADDR[1]   rise     121.7
control/read_addr[1]   rise     121.4
control/read_addr[1]'   rise      57.3
 control/GB.LP.I_248   fall       51.0
        control/read   rise       50.0
 host_interface/read   rise       49.4
host_interface/read'   rise       16.2
host_interface/GB.LP.I_298   fall       15.2
host_interface/GB.LP.I_61   rise      13.4
host_interface/GB.LP.I_262   rise       10.7
host_interface/PHASE_A   rise       8.8
```

```
    pixelclk/PHASE_A   rise       8.0
           pixel_clk   rise       0.0

 ** Minimum Cycle (Ph2) Time =   142.6 ns (clockdelay:8.3ns (151.0-142.6))
multD/coeff_bank/(internal)   fall     151.0
multD/coeff_bank/A_ADDR[1]   rise     150.5
control/read_addr[1]   rise     150.3
control/read_addr[1]'   rise      86.1
 control/GB.LP.I_248   fall      79.8
        control/read   rise      78.8
 host_interface/read   rise      78.2
host_interface/read'   rise      45.1
host_interface/GB.LP.I_298   fall      44.0
host_interface/GB.LP.I_61   rise      42.3
*host_interface/(internal)   fall      39.8
host_interface/GB.LP.I_54   rise      39.6
host_interface/GB.LP.I_71   fall      37.4
host_interface/GB.LP.I_68   fall      35.0
host_interface/GB.LP.I_274   rise      34.4
host_interface/GB.LP.I_159   fall      33.1
host_interface/GB.LP.I_276   rise      32.2
host_interface/data_dis   fall      31.0
host_interface/data_dis'   fall      16.8
host_interface/GB.LP.I_149   rise      15.7
host_interface/GB.LP.I_294   fall      13.8
host_interface/GB.LP.I_152   rise      12.8
host_interface/GB.LP.I_161   fall      10.4
host_interface/GB.LP.I_290   rise       9.8
host_interface/GB.LP.I_155   fall       7.8
host_interface/id[2]   fall       5.4
  chip_id[2]/chip_id   fall       5.1
 chip_id[2]/chip_id'   fall       3.6
          Chip_id[2]   fall       0.0
tv_clkrpt() DONE


CLOCK_PERIOD VIOLATIONS: 0


tv_verify_clk() DONE
)  BACK


)  SETUP_HOLD

   Input name                Phase_1                Phase_2
                          (setup) (hold)         (setup) (hold)
            Addertest  (     ---     ---)  (     7.1    -1.3)
       Begin_frame_in  (     ---     ---)  (     4.7     1.2)
         Begin_row_in  (     ---     ---)  (     5.7     1.2)
           Chip_id[0]  (     ---     ---)  (   116.0    -6.5)
           Chip_id[1]  (     ---     ---)  (   116.4    -6.9)
           Chip_id[2]  (     ---     ---)  (   117.5    -8.0)
           Chip_id[3]  (     ---     ---)  (   114.5    -5.1)
              Data[0]  (     ---     ---)  (    -1.0     3.3)
             Data[10]  (     ---     ---)  (    -0.2     2.1)
             Data[11]  (     ---     ---)  (    -0.1     1.9)
             Data[12]  (     ---     ---)  (    -0.2     2.1)
             Data[13]  (     ---     ---)  (    -0.8     2.9)
             Data[14]  (     ---     ---)  (    -0.3     2.3)
```

```
          Data[15]  (     ---      ---)  (    -0.4      2.3)
           Data[1]  (     ---      ---)  (    -0.6      2.8)
           Data[2]  (     ---      ---)  (    -0.7      2.9)
           Data[3]  (     ---      ---)  (    -0.6      2.8)
           Data[4]  (     ---      ---)  (    -0.6      2.8)
           Data[5]  (     ---      ---)  (    -0.2      2.2)
           Data[6]  (     ---      ---)  (    -0.2      2.2)
           Data[7]  (     ---      ---)  (    -0.5      2.5)
           Data[8]  (     ---      ---)  (    -0.4      2.4)
           Data[9]  (     ---      ---)  (    -0.3      2.2)
      Dev_select[0]  (     ---      ---)  (   115.6     -6.5)
      Dev_select[1]  (     ---      ---)  (   116.1     -7.0)
      Dev_select[2]  (     ---      ---)  (   116.3     -7.1)
      Dev_select[3]  (     ---      ---)  (   113.5     -4.4)
       End_frame_in  (     ---      ---)  (     6.7     -1.8)
         End_row_in  (     ---      ---)  (    15.0      0.2)
       Host_addr[0]  (     ---      ---)  (    -0.3      3.5)
       Host_addr[1]  (     ---      ---)  (    -0.2      3.5)
       Host_addr[2]  (     ---      ---)  (    -0.3      3.5)
       Host_addr[3]  (     ---      ---)  (    -0.5      3.8)
       Host_addr[4]  (     ---      ---)  (     0.1      3.2)
              Ios    (     ---      ---)  (     1.9      1.9)
         Multtest    (     ---      ---)  (    47.1     -6.6)
          N_reset    (    21.2    -16.1)  (    20.8    -10.5)
              Ode    (     ---      ---)  (   107.8      0.3)
       Pixel_in[0]   (     ---      ---)  (    -1.2      4.9)
      Pixel_in[10]   (     ---      ---)  (    -0.9      4.6)
      Pixel_in[11]   (     ---      ---)  (    -0.8      4.5)
      Pixel_in[12]   (     ---      ---)  (    -0.4      4.1)
      Pixel_in[13]   (     ---      ---)  (    -0.1      3.8)
      Pixel_in[14]   (     ---      ---)  (    -0.6      4.2)
      Pixel_in[15]   (     ---      ---)  (    -0.4      4.0)
       Pixel_in[1]   (     ---      ---)  (    -1.6      5.3)
       Pixel_in[2]   (     ---      ---)  (    -1.2      4.9)
       Pixel_in[3]   (     ---      ---)  (    -1.3      5.0)
       Pixel_in[4]   (     ---      ---)  (    -1.5      5.3)
       Pixel_in[5]   (     ---      ---)  (    -1.3      5.1)
       Pixel_in[6]   (     ---      ---)  (    -1.1      4.9)
       Pixel_in[7]   (     ---      ---)  (    -1.2      4.9)
       Pixel_in[8]   (     ---      ---)  (    -1.1      4.8)
       Pixel_in[9]   (     ---      ---)  (    -1.0      4.7)
tv_input() DONE
  BACK


  OUTPUT_DELAY

Begin_frame_out  (min1=   25.8 max1=   44.6)  (min2=    --- max2=    ---) (loa
  Begin_row_out  (min1=   31.3 max1=   50.1)  (min2=    --- max2=    ---) (loa
       DR_n_aDR  (min1=   19.6 max1=   31.7)  (min2=   19.6 max2=   26.3) (loa
        Data[0]  (min1=    0.0 max1=   43.2)  (min2=    0.0 max2=   43.2) (loa
       Data[10]  (min1=    0.0 max1=   43.0)  (min2=    0.0 max2=   43.0) (loa
       Data[11]  (min1=    0.0 max1=   43.0)  (min2=    0.0 max2=   43.0) (loa
       Data[12]  (min1=    0.0 max1=   43.0)  (min2=    0.0 max2=   43.0) (loa
       Data[13]  (min1=    0.0 max1=   42.9)  (min2=    0.0 max2=   42.9) (loa
       Data[14]  (min1=    0.0 max1=   42.9)  (min2=    0.0 max2=   42.9) (loa
       Data[15]  (min1=    0.0 max1=   42.9)  (min2=    0.0 max2=   42.9) (loa
        Data[1]  (min1=    0.0 max1=   43.2)  (min2=    0.0 max2=   43.2) (loa
        Data[2]  (min1=    0.0 max1=   43.2)  (min2=    0.0 max2=   43.2) (loa
```

```
        Data[3]  (min1=     0.0 max1=    43.2)  (min2=     0.0 max2=    43.2) (loa
        Data[4]  (min1=     0.0 max1=    43.2)  (min2=     0.0 max2=    43.2) (loa
        Data[5]  (min1=     0.0 max1=    43.1)  (min2=     0.0 max2=    43.1) (loa
        Data[6]  (min1=     0.0 max1=    43.1)  (min2=     0.0 max2=    43.1) (loa
        Data[7]  (min1=     0.0 max1=    43.1)  (min2=     0.0 max2=    43.1) (loa
        Data[8]  (min1=     0.0 max1=    43.1)  (min2=     0.0 max2=    43.1) (loa
        Data[9]  (min1=     0.0 max1=    43.0)  (min2=     0.0 max2=    43.0) (loa
  End_frame_out  (min1=    26.2 max1=    32.8)  (min2=     --- max2=     ---) (loa
    End_row_out  (min1=    28.8 max1=    35.8)  (min2=     --- max2=     ---) (loa
     Pix_lsb[0]  (min1=    30.9 max1=   188.5)  (min2=    30.9 max2=   168.3) (loa
     Pix_lsb[1]  (min1=    31.0 max1=   188.6)  (min2=    31.0 max2=   168.4) (loa
     Pix_lsb[2]  (min1=    31.1 max1=   188.7)  (min2=    31.1 max2=   168.6) (loa
     Pix_msb[0]  (min1=    30.3 max1=   189.1)  (min2=    30.3 max2=   168.9) (loa
     Pix_msb[1]  (min1=    30.3 max1=   190.2)  (min2=    30.3 max2=   170.1) (loa
     Pix_msb[2]  (min1=    30.4 max1=   191.1)  (min2=    30.4 max2=   170.9) (loa
    Pixel_out[0]  (min1=    29.6 max1=   186.9)  (min2=    29.6 max2=   166.8) (loa
   Pixel_out[10]  (min1=    29.3 max1=   186.6)  (min2=    29.3 max2=   166.4) (loa
   Pixel_out[11]  (min1=    28.9 max1=   186.1)  (min2=    28.9 max2=   166.0) (loa
   Pixel_out[12]  (min1=    28.5 max1=   185.6)  (min2=    28.5 max2=   165.4) (loa
   Pixel_out[13]  (min1=    28.4 max1=   185.5)  (min2=    28.4 max2=   165.3) (loa
   Pixel_out[14]  (min1=    28.3 max1=   185.3)  (min2=    28.3 max2=   165.1) (loa
   Pixel_out[15]  (min1=    28.2 max1=   186.3)  (min2=    28.2 max2=   166.1) (loa
    Pixel_out[1]  (min1=    29.5 max1=   186.9)  (min2=    29.5 max2=   166.7) (loa
    Pixel_out[2]  (min1=    30.4 max1=   187.9)  (min2=    30.4 max2=   167.8) (loa
    Pixel_out[3]  (min1=    30.0 max1=   187.5)  (min2=    30.0 max2=   167.4) (loa
    Pixel_out[4]  (min1=    29.9 max1=   187.4)  (min2=    29.9 max2=   167.2) (loa
    Pixel_out[5]  (min1=    29.8 max1=   187.2)  (min2=    29.8 max2=   167.1) (loa
    Pixel_out[6]  (min1=    29.7 max1=   187.1)  (min2=    29.7 max2=   166.9) (loa
    Pixel_out[7]  (min1=    29.6 max1=   187.0)  (min2=    29.6 max2=   166.8) (loa
    Pixel_out[8]  (min1=    29.5 max1=   186.8)  (min2=    29.5 max2=   166.7) (loa
    Pixel_out[9]  (min1=    29.4 max1=   186.7)  (min2=    29.4 max2=   166.5) (loa
            Sign  (min1=    51.9 max1=   154.7)  (min2=    51.9 max2=   134.6) (loa
tv_output() DONE
  BACK
  VIOLATIONS

INPUT VIOLATIONS: 0
tv_verify_input() DONE

OUTPUT VIOLATIONS: 0
tv_verify_output() DONE

Internal hold time check (Margin=1.7ns)
INFO: 4814 Phase_1 latches checked; 0 violations detected
INFO: 4966 Phase_2 latches checked; 0 violations detected
INFO: No internal hold time violations detected.
Internal hold time check done.
NO VIOLATIONS.

INFO:Selecting last corner used - 'GUARANTEED'
Operating condition changed: 150 deg C and 4.50v


  CLOCKS

Key Parameters (set 122) Modified
Phase 1 High =   104.7ns     Phase 2 High =  162.7 ns
Cycle (Ph1) =   158.8ns      Cycle (Ph2) =   197.3ns
Minimum Cycle Time =   267.4ns      Symmetric Cycle Time =   325.5ns
```

```
 ** Minimum Phase 1 High Time =   104.7 ns (clockdelay:12.5ns (117.2-104.7))
pipe/mem1/fifo1/(internal)     fall     117.2
pipe/mem1/fifo1/read_fifo1     rise     103.2
pipe/control/logic/read_fifo1     rise     103.0
pipe/control/logic/read_fifo1'     rise      87.7
pipe/control/logic/GB.LP.I_220     fall      87.0
pipe/control/logic/read_fifo2     rise      85.5
pipe/control/logic/read_fifo2'     rise      46.3
pipe/control/logic/GB.LP.I_265     fall      43.6
pipe/control/logic/valid_pixel     rise      42.8
<pe/control/logic/valid_pixel'     rise      19.6
pipe/control/logic/GB.LP.I_139     rise      15.9
pipe/control/logic/GB.LP.I_165     fall      15.3
pipe/control/logic/PHASE_A     rise      13.2
    pixelclk/PHASE_A     rise      11.0
           pixel_clk     rise       0.0

 ** Minimum Phase 2 High Time =   162.7 ns (clockdelay:6.3ns (169.1-162.7))
multD/coeff_bank/(internal)     fall     169.1
multD/coeff_bank/A_ADDR[1]     rise     167.3
control/read_addr[1]     rise     166.9
control/read_addr[1]'     rise      77.9
 control/GB.LP.I_248     fall      69.2
       control/read     rise      67.8
 host_interface/read     rise      67.0
host_interface/read'     rise      21.0
host_interface/GB.LP.I_298     fall      19.6
host_interface/GB.LP.I_152     rise      17.6
host_interface/GB.LP.I_161     fall      14.3
host_interface/GB.LP.I_290     rise      13.5
host_interface/GB.LP.I_155     fall      10.7
host_interface/id[2]     fall       7.4
  chip_id[2]/chip_id     fall       7.0
 chip_id[2]/chip_id'     fall       4.9
         Chip_id[2]     fall       0.0


 ** Minimum Cycle (Ph1) Time =   158.8 ns (clockdelay:12.9ns (171.7-158.8))
multB/coeff_bank/225   fall     171.7
*multB/coeff_bank/(internal)   fall     169.1
multB/coeff_bank/A_ADDR[1]   rise     168.5
control/read_addr[1]   rise     168.2
control/read_addr[1]'   rise      79.2
 control/GB.LP.I_248   fall      70.4
       control/read   rise      69.0
 host_interface/read   rise      68.2
host_interface/read'   rise      22.2
host_interface/GB.LP.I_298   fall      20.8
host_interface/GB.LP.I_61   rise      18.4
host_interface/GB.LP.I_262   rise      14.7
host_interface/PHASE_A   rise      12.2
    pixelclk/PHASE_A   rise      11.0
           pixel_clk   rise       0.0

 ** Minimum Cycle (Ph2) Time =   197.3 ns (clockdelay:11.5ns (208.8-197.3))
multD/coeff_bank/(internal)   fall     208.8
multD/coeff_bank/A_ADDR[1]   rise     208.2
control/read_addr[1]   rise     207.9
control/read_addr[1]'   rise     118.9
 control/GB.LP.I_248   fall     110.1
```

```
        control/read   rise     108.7
 host_interface/read   rise     107.9
host_interface/read'   rise      61.9
host_interface/GB.LP.I_298   fall      60.5
host_interface/GB.LP.I_61   rise      58.1
*host_interface/(internal)   fall      54.7
host_interface/GB.LP.I_54   rise      54.4
host_interface/GB.LP.I_71   fall      51.4
host_interface/GB.LP.I_68   fall      48.2
host_interface/GB.LP.I_274   rise      47.4
host_interface/GB.LP.I_159   fall      45.7
host_interface/GB.LP.I_276   rise      44.5
host_interface/data_dis   fall      42.7
host_interface/data_dis'   fall      23.0
host_interface/GB.LP.I_149   rise      21.6
host_interface/GB.LP.I_294   fall      19.0
host_interface/GB.LP.I_152   rise      17.6
host_interface/GB.LP.I_161   fall      14.3
host_interface/GB.LP.I_290   rise      13.5
host_interface/GB.LP.I_155   fall      10.7
host_interface/id[2]   fall       7.4
  chip_id[2]/chip_id   fall       7.0
 chip_id[2]/chip_id'   fall       4.9
          Chip_id[2]   fall       0.0
tv_clkrpt() DONE

CLOCK_PERIOD VIOLATIONS: 0
tv_verify_clk() DONE


  SETUP_HOLD

   Input name                Phase_1                Phase_2
                          (setup)  (hold)        (setup)  (hold)
          Addertest  (     ---      ---)   (     9.4     -1.8)
      Begin_frame_in  (     ---      ---)   (     6.2      1.6)
        Begin_row_in  (     ---      ---)   (     7.9      1.6)
          Chip_id[0]  (     ---      ---)   (   160.7     -8.8)
          Chip_id[1]  (     ---      ---)   (   161.2     -9.4)
          Chip_id[2]  (     ---      ---)   (   162.7    -10.9)
          Chip_id[3]  (     ---      ---)   (   158.7     -7.0)
             Data[0]  (     ---      ---)   (    -1.4      4.5)
            Data[10]  (     ---      ---)   (    -0.3      2.9)
            Data[11]  (     ---      ---)   (    -0.2      2.6)
            Data[12]  (     ---      ---)   (    -0.3      2.9)
            Data[13]  (     ---      ---)   (    -1.1      3.9)
            Data[14]  (     ---      ---)   (    -0.5      3.1)
            Data[15]  (     ---      ---)   (    -0.6      3.2)
             Data[1]  (     ---      ---)   (    -0.8      3.8)
             Data[2]  (     ---      ---)   (    -0.9      4.0)
             Data[3]  (     ---      ---)   (    -0.8      3.8)
             Data[4]  (     ---      ---)   (    -0.8      3.8)
             Data[5]  (     ---      ---)   (    -0.4      2.9)
             Data[6]  (     ---      ---)   (    -0.4      2.9)
             Data[7]  (     ---      ---)   (    -0.7      3.4)
             Data[8]  (     ---      ---)   (    -0.6      3.3)
             Data[9]  (     ---      ---)   (    -0.4      3.0)
       Dev_select[0]  (     ---      ---)   (   160.2     -8.8)
       Dev_select[1]  (     ---      ---)   (   160.8     -9.5)
       Dev_select[2]  (     ---      ---)   (   161.1     -9.5)
```

```
      Dev_select[3]  (     ---      ---)  (  157.3    -6.0)
       End_frame_in  (     ---      ---)  (    9.3    -2.5)
         End_row_in  (     ---      ---)  (   20.4     0.2)
       Host_addr[0]  (     ---      ---)  (   -0.4     4.8)
       Host_addr[1]  (     ---      ---)  (   -0.4     4.8)
       Host_addr[2]  (     ---      ---)  (   -0.4     4.9)
       Host_addr[3]  (     ---      ---)  (   -0.8     5.2)
       Host_addr[4]  (     ---      ---)  (    0.1     4.3)
              Ios    (     ---      ---)  (    2.5     2.6)
          Multtest   (     ---      ---)  (   65.2    -9.0)
           N_reset   (    29.3    -22.5)  (   28.8   -14.7)
               Ode   (     ---      ---)  (  149.5     0.3)
        Pixel_in[0]  (     ---      ---)  (   -1.7     6.6)
       Pixel_in[10]  (     ---      ---)  (   -1.3     6.2)
       Pixel_in[11]  (     ---      ---)  (   -1.1     6.0)
       Pixel_in[12]  (     ---      ---)  (   -0.7     5.6)
       Pixel_in[13]  (     ---      ---)  (   -0.2     5.0)
       Pixel_in[14]  (     ---      ---)  (   -0.9     5.7)
       Pixel_in[15]  (     ---      ---)  (   -0.6     5.4)
        Pixel_in[1]  (     ---      ---)  (   -2.3     7.3)
        Pixel_in[2]  (     ---      ---)  (   -1.7     6.6)
        Pixel_in[3]  (     ---      ---)  (   -1.8     6.8)
        Pixel_in[4]  (     ---      ---)  (   -2.2     7.2)
        Pixel_in[5]  (     ---      ---)  (   -1.9     6.9)
        Pixel_in[6]  (     ---      ---)  (   -1.6     6.6)
        Pixel_in[7]  (     ---      ---)  (   -1.7     6.6)
        Pixel_in[8]  (     ---      ---)  (   -1.6     6.5)
        Pixel_in[9]  (     ---      ---)  (   -1.5     6.4)
tv_input() DONE          tmA      thA        taB      tbB
)  BACK


)  OUTPUT_DELAY                    todB

 Begin_frame_out  (min1=   35.4 max1=   61.5)  (min2=    --- max2=    ---) (loa
   Begin_row_out  (min1=   43.0 max1=   69.1)  (min2=    --- max2=    ---) (loa
         DR_n_aDR (min1=   26.8 max1=   43.4)  (min2=   26.8 max2=   36.2) (loa
          Data[0] (min1=    0.0 max1=   59.7)  (min2=    0.0 max2=   59.7) (loa
         Data[10] (min1=    0.0 max1=   59.4)  (min2=    0.0 max2=   59.4) (loa
         Data[11] (min1=    0.0 max1=   59.3)  (min2=    0.0 max2=   59.3) (loa
         Data[12] (min1=    0.0 max1=   59.3)  (min2=    0.0 max2=   59.3) (loa
         Data[13] (min1=    0.0 max1=   59.3)  (min2=    0.0 max2=   59.3) (loa
         Data[14] (min1=    0.0 max1=   59.2)  (min2=    0.0 max2=   59.2) (loa
         Data[15] (min1=    0.0 max1=   59.2)  (min2=    0.0 max2=   59.2) (loa
          Data[1] (min1=    0.0 max1=   59.7)  (min2=    0.0 max2=   59.7) (loa
          Data[2] (min1=    0.0 max1=   59.7)  (min2=    0.0 max2=   59.7) (loa
          Data[3] (min1=    0.0 max1=   59.7)  (min2=    0.0 max2=   59.7) (loa
          Data[4] (min1=    0.0 max1=   59.6)  (min2=    0.0 max2=   59.6) (loa
          Data[5] (min1=    0.0 max1=   59.5)  (min2=    0.0 max2=   59.5) (loa
          Data[6] (min1=    0.0 max1=   59.5)  (min2=    0.0 max2=   59.5) (loa
          Data[7] (min1=    0.0 max1=   59.5)  (min2=    0.0 max2=   59.5) (loa
          Data[8] (min1=    0.0 max1=   59.4)  (min2=    0.0 max2=   59.4) (loa
          Data[9] (min1=    0.0 max1=   59.4)  (min2=    0.0 max2=   59.4) (loa
   End_frame_out  (min1=   36.0 max1=   45.2)  (min2=    --- max2=    ---) (loa
     End_row_out  (min1=   39.6 max1=   49.4)  (min2=    --- max2=    ---) (loa
      Pix_lsb[0]  (min1=   42.5 max1=  258.2)  (min2=   42.5 max2=  230.7) (loa
      Pix_lsb[1]  (min1=   42.6 max1=  258.3)  (min2=   42.6 max2=  230.9) (loa
      Pix_lsb[2]  (min1=   42.8 max1=  258.5)  (min2=   42.8 max2=  231.1) (loa
      Pix_msb[0]  (min1=   41.7 max1=  258.5)  (min2=   41.7 max2=  231.1) (loa
```

```
     Pix_msb[1]  (min1=   41.7 max1=  260.1)  (min2=   41.7 max2=  232.6) (loa
     Pix_msb[2]  (min1=   41.8 max1=  261.2)  (min2=   41.8 max2=  233.8) (loa
   Pixel_out[0]  (min1=   40.7 max1=  256.0)  (min2=   40.7 max2=  228.6) (loa
  Pixel_out[10]  (min1=   40.4 max1=  255.6)  (min2=   40.4 max2=  228.2) (loa
  Pixel_out[11]  (min1=   39.9 max1=  254.9)  (min2=   39.9 max2=  227.5) (loa
  Pixel_out[12]  (min1=   39.2 max1=  254.1)  (min2=   39.2 max2=  226.7) (loa
  Pixel_out[13]  (min1=   39.1 max1=  254.0)  (min2=   39.1 max2=  226.6) (loa
  Pixel_out[14]  (min1=   38.9 max1=  253.8)  (min2=   38.9 max2=  226.3) (loa
  Pixel_out[15]  (min1=   38.8 max1=  254.6)  (min2=   38.8 max2=  227.2) (loa
   Pixel_out[1]  (min1=   40.6 max1=  255.9)  (min2=   40.6 max2=  228.5) (loa
   Pixel_out[2]  (min1=   41.8 max1=  257.4)  (min2=   41.8 max2=  230.0) (loa
   Pixel_out[3]  (min1=   41.4 max1=  256.8)  (min2=   41.4 max2=  229.4) (loa
   Pixel_out[4]  (min1=   41.2 max1=  256.6)  (min2=   41.2 max2=  229.2) (loa
   Pixel_out[5]  (min1=   41.0 max1=  256.4)  (min2=   41.0 max2=  229.0) (loa
   Pixel_out[6]  (min1=   40.9 max1=  256.2)  (min2=   40.9 max2=  228.8) (loa
   Pixel_out[7]  (min1=   40.8 max1=  256.1)  (min2=   40.8 max2=  228.7) (loa
   Pixel_out[8]  (min1=   40.6 max1=  255.9)  (min2=   40.6 max2=  228.4) (loa
   Pixel_out[9]  (min1=   40.5 max1=  255.7)  (min2=   40.5 max2=  228.3) (loa
           Sign  (min1=   71.0 max1=  211.8)  (min2=   71.0 max2=  184.3) (loa
 tv_output() DONE
)  BACK
)  VIOLATIONS
 INPUT VIOLATIONS: 0
 tv_verify_input() DONE
 OUTPUT VIOLATIONS: 0
 tv_verify_output() DONE
 Internal hold time check (Margin=2.0ns)
 INFO: 4814 Phase_1 latches checked; 0 violations detected
 INFO: 4966 Phase_2 latches checked; 0 violations detected
 INFO: No internal hold time violations detected.
 Internal hold time check done.
 NO VIOLATIONS.
)  BACK
 **** END   Command File 'timing'
ACK
ONFIRM
XIT_GENESIL
o ke
 ********************************************************************************
           ^^^^^^^^ GENESIL Client session log is above ^^^^^^^^

           vvvvvvvv GENESIL Server session log is below vvvvvvvv
 ********************************************************************************
 End of GENESIL session '30_Jan_1'
```